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Sir R. S. BALL, M.A., LL.D., F.R.S., President, in the Chair.

Arthur W. Clayden, M.A., F.G.S., St. John's, Polsloe Road,
Exeter; and

Herbert Lovis Noel Noel-Cox, 2 Edinburgh Mansions,
Victoria Street, S.W.,

were balloted for and duly elected Fellows of the Society.

Seventy-eight presents were announced as having been received since the last meeting, including, amongst others :—

E. S. Holden, Mountain Observatories, presented by the Author; J. A. C. Oudemans, Triangulation von Java, Abtheilung V., presented by the Netherlands Government; J. Milne and W. K. Burton, The Great Earthquake in Japan, presented by Professor Milne; Lick Observatory Atlas of the Moon, plates 2-5, presented by the Observatory; Harvard College Observatory, photographs taken with the Bruce telescope, presented by the Observatory; Photograph of *Jupiter* by Warren De la Rue, presented by Mr. G. F. Pollock; Lantern slides of the Sun-spots of May 1897, presented by Mr. Newbegin.

On the Various Forms of Personal Equation in Meridian Transits of Stars. By Truman Henry Safford.

The first and historically the most important form of personal equation is that discovered by Bessel in the use of the eye and ear method.

In Bessel's Memoir we find the examples of large personal equations which are most frequently quoted; and to illustrate some of the points I will repeat them. Bessel anticipated Argelander $1^s.22$ by eye and ear, and also anticipated W. Struve by $0^s.8$. This last value held good strictly for the year 1821, and at that time it was indirectly obtained through Walbeck; and a closer agreement of Bessel and Struve, B.-S. = $-0^s.044$, is sometimes quoted. It was found in 1814; and the evidence for it is slight, one transit of *a Lyrae* by Struve and one each of *a Andromeda* and γ *Pegasi* observed by Bessel. It is not unfair to suspect that the apparent change in Struve's personal equation relatively to Bessel from $0^s.04$ in 1814 to $0^s.8$ in 1821 was due to irregularity of clock rate on 1814 October 21, more than to a change in the personal equation of either astronomer.¹ *Fomalhaut*, observed by Bessel and Struve 1820 November 13, gave Bessel-Struve = $-0^s.68$, but the observation was passed over as too near the horizon of Königsberg, where the star's altitude was $4^{\circ}1.2$; yet it agrees well enough with later determinations of Bessel and Struve's personal equation.

Bessel and Argelander inferred from their unprecedented difference of $1^s.22$ that Bessel anticipated the true time of transits, while Argelander fell behind it. Bessel, when he used a half-seconds timepiece, observed $0^s.5$ later than with the sidereal clock; hence his anticipation with the latter was more than $0^s.5$; and we risk but little in considering Bessel's difference of $0^s.8$ from W. Struve was mainly due to himself and not to Struve. I believe astronomers in general would agree with this opinion. In 1843 and 1844 Struve was compared with all the observers who took part in the chronometric expeditions of those years, between Pulkova, Greenwich, and Altona, and from these comparisons we find that he agrees within a few hundredths of a second with the general average, including O. Struve, who was the standard observer for the expedition of 1844, and was also nearly an average observer. The comparisons with Bessel give rise to the suspicion that an average of eye and ear observations, giving each observer equal weight, might perhaps be seriously in error.

If we take the equations Bessel-Struve = $-0^s.8$, Bessel-Argelander = $-1^s.2$, we find enough residual error in the mean result of the observers on almost any theory to leave the conclusion as to the true average observer somewhat doubtful.

¹ The clock's daily rate as used was $5^m.92$.

The subject has since 1885 been thoroughly followed up at Greenwich by the combination of the eye and ear and chronographic methods,* and the various older examples of large personal equation which are upon record ; for instance

Maskelyne-Kinnebrook	1795 = - 0 ^s . 8
Main-Rogerson	1853 = - 0 ^s . 7
Main-Lucas	1871, 1872 = - 0 ^s . 76

are worth mentioning in connection with the material accumulated since 1885, chiefly to show that absolute personal errors of considerable magnitude, 0^s.5 or more, are to be found in either direction, and not solely as anticipations.

Observers of Argelander's type who set down transits by eye and ear 0^s.4 too late are not often found ; and yet that an error of more than 0^s.3 must exist in the case of some observers is plain ; so that the fact that either Bessel or Argelander observed transits more than 0^s.6 too early or too late does not seem as difficult to comprehend as it did many years ago. Mr. Main, for example, was a transit observer of Argelander's type, as was the luckless Kinnebrook in 1795 ; and Maskelyne anticipated three assistants—Dymond, Bayley, and Hitchens—by 0^s.27, 0^s.18, and 0^s.14 respectively ; and if the average 0^s.20 of these three quantities is taken as an indication, he was much like most modern observers in his manner of noting transits.

In order to put the data of the later Greenwich introductions into a shape for farther discussion, I have brought together the quantities $e' - e$ for the twenty observers who have taken part in the eye and ear transits since 1885, when the practice of observing time-stars by this method was resumed after its disuse about 1859. Of the twenty observers eight are assistants and twelve computers.

By e' I denote the amount by which each observer anticipated by eye and ear the standard chronographic transits of the Royal Observatory ; by e I denote the similar amount by which he anticipated the standard transits by chronographic registration on his own part. Hence $e' - e$ (for the standard observer $e = 0$) is the amount by which each observer when he uses the eye and ear method anticipates the standard chronographic transits ; and on reading over the Introductions to the Greenwich Observations we find that for the standard observers e' , and for the others $e' - e$, is persistently positive for the whole period from 1885 to 1893 inclusive. For A. D., who served as standard observer till 1890 inclusive, and for eye and ear in 1891, we find the mean of seven values of $e' = +0^s.123$, and for L., standard observer in the two years 1892 and 1893, we find $e' = +0^s.19$ and $+0^s.20$ respectively. But as L. was one of the principal observers for the whole nine

* The earlier discussions at Greenwich refer to the eye and ear method, or the chronographic method used separately but not together.

years, we can readily set down the amounts $e' - e$ by which he anticipated his own chronographic transits for all these years.

For example, in 1885 e' for L. is $+0^s.08$ and $e + 0^s.02$; hence in that year L. anticipated by eye and ear his own chronographic transits by $0^s.06$. The sum of the nine values of $e' - e$ is $1^s.27$ and the mean $0^s.141$, hence L.'s mean anticipation of his own chronographic transits is slightly more than that of A. D., the former standard observer.

It would be unsafe to base any generalisation upon the work of two observers only, however skilful and experienced. For the period 1885-1893 there were in service three other astronomers who took a large share in the transit circle observations for nearly all the years, and we find the mean value of $e' - e$ for them to be as follows:—For H. T. $+0^s.030$, seven years, or including a single observation of 1893 with half the weight of a year,

$$+0^s.052 \quad 7\frac{1}{2} \text{ years.}$$

For T,

$$+0^s.033 \quad 6 \text{ years.}$$

The case of one observer, H., has been stated, so far as his chronographic transits are concerned, in *The Observatory* for May 1896.

The mean $e' - e$ for him for the nine years is $+0^s.511$.

Three other assistants took part in the eye and ear observations in 1892 and 1893. The values of $e' - e$ for them are respectively,

$$\text{A. C. 1892 } e' - e = +0^s.20$$

$$\text{A. C. 1893 } e' - e = +0^s.10$$

$$\text{B. 1892 } e' - e = +0^s.07$$

$$\text{B. 1893 } e' - e = -0^s.01$$

$$\text{T. H. 1893 } e' - e = +0^s.22$$

For the twelve computers tested from time to time between 1889 and 1893 we find a single one (and he is the junior computer tested in 1893 only) for whom the mean value of $e' - e$ is negative, and this for him represents one determination of e' only. For him $e' - e = 0^s.03$, considerably less than its probable error. Considering all the separate years' results, $e' - e$ for computers as units, we find of the nineteen such results the sum to be $1^s.66$, and their average $0^s.087$. This average would be modified by assignment of varying weights, but cannot be rendered negative.

The outcome of the investigation into the comparative personal equation by the two methods indicates that in the great majority of cases skilled eye and ear observers anticipate their own chronographic transits by amounts in general not far from $0^s.1$. But the observers previously mentioned (like Argelander), who fell behind the true time of transit as much as about $0^s.4$,

require attention at this point. These observers, so far as Greenwich is concerned, seem to be the following :—Kinnebrook 1795, Henry and Main (who nearly agreed with each other) in 1839 and some following years, and W. Ellis in the two or three years which just preceded the introduction in 1854 of the chronograph.

At any rate, the large majority of the Greenwich observers for a century have been men of the "anticipatory" type, if I may so call those who set down eye and ear transits too early as compared with their own chronographic registration or with average observers.

This represents, according to the best evidence I can gather, the following two principles :—

First, that the eye and ear method gives transits of time-stars which by different observers may be set down either too early or too late, but on the average of a number of skilled observers will be nearly correct, and the chronographic method, on the other hand, results in "observed" times of transit which are, on the average, too late by about 0^s.1 or more.

The eye and ear method and its results were discussed by Bessel in his classical memoirs reprinted in Engelmann's collection of the *Abhandlungen*, vol. iii. Argelander, as appears from the *Bonn Observations*, vol. vi. p. 11, accepted Bessel's theory, that Bessel "proceeded from hearing to seeing," while Argelander, to use his own words, "first saw and then heard." The question was tested in 1861 by the psychologist Wundt by simple experiments with a heavy pendulum, and he found that observers were, in fact, of the two types; some of them mentally fixed the place of the moving object too far ahead in its course, and others not far enough.

With the star's images the same is doubtless the case, and the observer's habit of fixing the place mentally at the clock-beat is thus rendered measurable as a psychological phenomenon. Wundt and others have tested also the "simple reaction to a sense impression," and have found out how long it takes an observer to register an impression on any of his senses by using in the registry chronographs or chronoscopes imitated from the astronomical apparatus. It is found that in general the time occupied is from one-tenth to two-tenths of a second, and it is also found that there are two methods of registering, the "muscular" and the "sensorial," and that the "sensorial," in which the observer waits till he is sure of the sense impression, generally occupies 0^s.1 or more longer than the other in which the observer's attention is concentrated upon performing the act of registration. This, too, is confirmed by the astronomical experience of L. and H. (*The Observatory* for May 1896), as well as of Dr. Battermann, who employs the slower method in very precise observations of transits of faint stars.

The conclusions of this paper so far may be thus stated. The experience of observers since 1795 shows that most eye and ear

observers anticipate the true time of transits, at least if the average observer is taken as the standard.

The Greenwich experiments since 1885 indicate that the great majority when they use the eye and ear method almost without exception anticipate the time of their own chronographic transits ; that the average chronographic observer registers transits after the time of their occurrence by an amount not greatly different from that which is required to register an impression on the senses ; that the difference between the sensorial and muscular methods of "reaction" is confirmed by the experience of L. and H., for ten years at Greenwich.

A question which Bessel left not wholly answered, viz. : "Whether his observations of polar and equatorial stars were homogeneous," has lately assumed some importance ; but I must defer till another occasion the computations which I have made, and which show that the Greenwich right ascensions of polar stars since 1889, observed by a new method, are in close accordance with the Berlin *Jahrbuch*, which has been taken as a standard in this respect by a good many observers and has much weight.

The differences between the right ascensions of standard polar stars as derived from the absolute observations, successive double culminations observed by various astronomers, have often attracted enough attention to be mentioned, but have been usually treated as a matter of no great importance. Thus, for instance, Preuss obtained a greater right ascension of *Polaris* than W. Struve did, but the difference 0^s.84 was possibly due to other causes.

In the arrangements for the Pulkova fundamental catalogue of 1845 this point was carefully attended to by Struve and his assistants ; *Polaris* and other polar stars were observed by the individual astronomers with the following results in right ascension for 1845^o.

For *Polaris* :

						h	m	s
Schweizer	...	...	...	...	511 observations	1	3	35.74
Fuss	...	...	...	...	29	..		34.71
Lindhagen	...	...	...	...	65	..		35.22
Wagner	...	...	...	...	91	..		35.36

For *H Cephei* 51 :

Schweizer	...	...	...	...	11	..	6 25	59.66
Lindhagen	...	...	...	...	7	..		59.22
Wagner	...	...	...	...	28	..		59.28

For δ *Ursæ Minoris* :

Schweizer	...	...	...	...	170	..	18 22	19.75
Fuss	...	...	...	...	23	..		19.45
Lindhagen	...	...	...	...	17	..		19.72
Wagner	...	...	...	...	55	..		19.56

It will be seen that Schweizer, who observed time-stars very nearly as W. Struve did, and was in that respect very nearly an average observer, assigned larger right ascensions to all three stars than Wagner, while his difference in the same direction from Fuss, who, however, did not observe *H Cephei* 51, was also considerable. We have for *Polaris*, Schweizer-Fuss = $1^s.03$, or for δ *Ursæ Minoris*, Schweizer-Fuss = $0^s.30$ or $0''.27$, reduced to the equator.

(From a paper by Mr. Sokoloff on the movement of the pole as determined by transit observations, in *Mélanges Mathématiques et Astronomiques*, vol. viii. p. 799.)

Similar differences to those between the Pulkova observers about 1845 are indicated among those of 1880 to 1887.

The following are the corrections of the assumed right ascensions of the three polars, *Polaris*, *H Cephei* 51, and δ *Ursæ Minoris*, as observed since 1880 by three observers employing both the eye and ear method and chronographic registration.

(1) Observations by eye and ear :

	<i>Polaris</i> , s	<i>H Cephei</i> 51, s	δ <i>Ursæ Minoris</i> , s
Wagner	-0.12	-0.33	-0.22
Wittram	-0.24	-0.33	-0.21
Harzer	-0.76	-0.61	-0.51

(2) Registered observations :

Wagner	+0.45	+0.10	+0.11
Wittram	-0.39	-0.28	-0.13
Harzer	-0.68	-0.58	-0.41

The vol. i. lately published of the *Annals of the Strassburg Observatory* affords indications of similar differences in the observations of *Polaris* chronographically registered.

The observers were Professor Schur, acting director, and Messrs. Wislicenus, Stechert, Kaufmann, and Dr. Leitzmann. The observations, like those for the Pulkova fundamental catalogues, were referred to the meridian by the help of marks with long focus lenses, the construction attributed to Rittenhouse, introduced at Pulkova by W. Struve. Hence the corrections to the tabular right ascension are based upon double culminations. These corrections denoted by χ are given by Professor Becker as follows :—

χ for Schur	...	...	...	...	s	mean error	s
Wislícenus	...	...	...	...	-0.58	±0.21	
"	"	...	...	...	-0.54	"	±0.13
"	"	...	...	...	-0.68	"	±0.12
" Kaufmann	...	...	...	...	+0.36	"	±0.10
"	"	...	...	...	-0.02	"	±0.46
" Stechert	...	...	...	...	+0.98	"	±0.30
" Leitzmann	...	...	...	...	+0.65	"	±0.36

The two groups of Dr. Wislicenus's observations are separated in the *Annals* because of an interchange of object-glass and eye-piece which might produce a slight difference through alteration of the field illumination. But the difference of the two quantities $-0^s.54$ and $-0^s.68$ is $0^s.14$; less than its mean error $\sqrt{(0^s.13)^2 + (0^s.12)^2}$ or $\pm 0^s.18$, so that we can combine the two groups into one result, $-0^s.62$, and we thus see that Dr. Wislicenus observes *Polaris* nearly uniformly with Professor Schur, and decidedly earlier than either Kaufmann, Stechert, or Leitzmann. His difference from Dr. Stechert is $1^s.60$, about five times its mean error, and from Dr. Leitzmann $1^s.27$, with a mean error of not quite a third of the amount.

It will now be seen that a "polar equation," as I may call it, is indicated for the Pulkova observers of 1845 and for their successors since 1880, and also for the Strassburg astronomers of 1883-1888.

But without some process which shall pretty thoroughly eliminate these differences no definite standard can easily be fixed; or, in other words, no standard catalogue of polar right ascensions is practicable, and the need of such a catalogue is apparent. The Greenwich method of observing transits of *Polaris* and the other azimuth stars is not known to be liable to any special personal equation, except the trifling difference between the registration by the two hands.

Of course the clock corrections are obtained by the ordinary methods, and as these produce an average error for time-stars amounting only to about a tenth of a second, we can see that its influence on the right ascension of *Polaris* and other close stars will be trifling. Moreover, the "muscular" method of registration, Professor Newcomb's Method A, is preferable for ordinary time-stars.

It is possible that the delay of the sensorial method, Method B, according to Newcomb, is different for polar and for equatorial stars, and it is not only desirable to investigate the "polar equation" for the standard azimuth stars, but for others of less declination, by both methods, Bradley's and the chronographic.

In Professors Helmer and Albrecht's work on the longitudes of the Prussian Geodetic Institute we find that the Repsold Transit Micrometer, which acts in an analogous manner to the "Greenwich Method," but in a wider range of declination, does good service, and reduces both ordinary personal equations and those referring to polar stars to a far less amount than previous experience indicates.

In attempting to fit a series of transit observations to a standard catalogue, the Pulkova astronomers have adopted a method which indicates the polar equations pretty clearly, and also shows how to eliminate it to a large extent. This process is most clearly set forth in Dr. Romberg's excellent catalogue of 5634 stars for 1875.

Romberg found in using the standard catalogue prepared by Vice-Director Wagner that his own tendency was to observe by eye and ear slow moving stars later by $0^s.025$ than Wagner, when for Wagner the mean results of his two methods, eye and ear and chronographic was taken. Romberg's observations at Pulkova began in 1877. Some years earlier, about 1870-1877, he had observed the fundamental stars of Wagner's list at Berlin, and his observations have been reduced by Dr. Marcuse.

The conclusion as to polar equation which I derive from Dr. Marcuse's work is that, at Berlin also, Romberg observed the polar stars later than the standard, the amount being about $0^s.019$, not quite so much as at Pulkova.

To eliminate this polar equation from the Pulkova secondary catalogues requires systematic corrections, and the process becomes a little intricate.

It is conceivable that in practice astronomers will be compelled to resort to the Repsold Micrometer for transits of stars more than 5° from the pole, or to photography.

At any rate, the extension of the "Greenwich Method" to greater polar distances is desirable if practicable. Meanwhile nothing is lost by following for the present the best modern practice in ordinary observations of transits.

There are six stars within 5° of the north pole whose right ascensions are regularly observed at Greenwich by the new method, and their co-ordinates are given in the Berlin *Jahrbuch* from Auwers's compilation and based upon the standard of Wagner's observations about 1865.

These six stars are:—1. *Cephei* 43=2 *Ursæ Minoris*; 2. *Polaris*; 3. Groombridge 750; 4. *Cephei* 51; 5. δ *Ursæ Minoris*; 6. λ *Ursæ Minoris*. Besides these there are six others which are also regularly observed in the same way, viz.:—

1. Groombridge 1119.
2. Bradley 1672.
3. Groombridge 2283.
4. Groombridge 3548.
5. *Cephei* 32=Bradley 2993.
6. *Cephei* 39=Bradley 3147.

Of the second list of six, No. 1, No. 3, and No. 4 are not in Bradley's catalogue, but all have been abundantly observed since 1814 by W. Struve and other astronomers, so that their proper motions can be accurately determined without applying doubtful systematic corrections to Piazzi or Groombridge, and the best standard polar catalogue for immediate use which I can suggest would be obtained from the Greenwich right ascensions 1889-1893, brought forward with proper motions obtained from the mass of existing reduced observations taken before 1889.

In the use of such a catalogue the observers should compare themselves with its standard by the process indicated in Romberg's

catalogue of 5634 stars ; that is, by determining polar deviations (Bessel's n) from close stars above and below pole and nearly at the same hours ; for instance, H Cephei 51 and δ Ursæ Minoris.

My own attempts to determine my "polar equation" by similar comparisons with the *Jahrbuch* standard are given in the *Williams College Catalogue of North Polar Stars*. I found that in the years 1882-1888 I observed by eye and ear slow moving stars relatively about $0^s.006$ later than the standard. By chronograph I observed about $0^s.010$ or $0^s.012$ later than the same standard. These quantities were so small that it was difficult to be certain of them, partly because of the small number of *Jahrbuch* stars available.

The difficulty of discriminating between Professor Smyth's 'instrumental swerving' and personal slowness with the polar stars could have been mitigated by the employment of a more extensive list of close polars, but this was impracticable, for the very stars were among those of such a list I wished to determine, and they were not to be mixed with the determining stars, and so the new Greenwich stars, Groombridge 1119, and the others were set down as observed only when their right ascensions were based upon instrumental corrections determined from Pulkova (*Jahrbuch*) stars. In other words, I did not employ Pond's method of fixing these particular zero points, but contented myself with adding $0^s.006$ to a value of n derived from an upper culmination, and subtracting that amount from an n derived from a lower culmination, or, in the cases when that was practicable, taking the mean of the two values of n , when of course the $+0^s.006$ and the $-0^s.006$ would cancel each other.

The Pulkova astronomers in 1893 examined their "polar equations" by eye and ear comparison again with the same standard of Wagner, and one of them, Mr. Ditschenko, has published a paper (*Mélanges Mathématiques et Astronomiques*, vol. vii., pp. 543-553) entitled "L'équation personnelle dans les observations des passages des étoiles polaires." He finds that, nearly as in 1877-1884, Romberg observed polar stars later than the standard by the amount $0^s.026$. But three other observers, Morine, Seraphimoff, and Ditschenko himself, observed them earlier, namely, $0^s.042$, $0^s.015$, and $0^s.025$ respectively, and the corresponding corrections are applied to the respective values of n , thus rendering them all homogeneous, but leaving right ascensions reduced by their aid still subject to the observed polar equation.

The observations of secondary right ascensions can be made more homogeneous by additional observations of secondary polars in various declinations by both the eye and ear, and the chronographic method, using as primary polar right ascensions those of Greenwich 1889-1893, and by comparing the results for azimuth or polar deviation from stars above and below pole, so as to apply the Pulkova correction to n , and then put on record the observer's peculiarity in that respect. The stars not in the

Greenwich list of twelve will in that case be affected with the observer's polar equation as the application of the Pulkova correction will eliminate the influence of their equation upon the polar deviations, but not on the final right ascension of the secondary stars so determined; for example, Romberg's Pulkova values of n were thus reduced to agreement with Wagner's standard, but not his determined right ascensions. These exhibit a tendency similar to that of his polar deviation; that is, he observed stars beyond the zenith of Pulkova or Berlin, respectively, later than the standard.

The light equation or *Helligkeits Gleichung* has been investigated by various astronomers and with very varying results.

It is found that by the chronograph observers register the transits of faint stars later than they do those of the brighter stars used for clock correction. The reason of this seems to be a psychological one; a faint impression on the senses is reacted to, according to Wundt and others, later than a stronger one, while by eye and ear a star plainly visible is observed at its transit more nearly in a uniform manner with the brighter ones. Argelander's experience is this: by eye and ear he noted the transits of very faint stars $0^s.48$ earlier than he did those of stars distinctly visible in his illuminated field. This he suspected, and Professor Auwers has confirmed his suspicion, and even over-confirmed it, for Argelander suspected his variations would be $0^s.2$ or $0^s.3$, and he correctly, it seems, attributed it to a reversal of his usual mental process of "seeing first and then hearing." The stars to which the usual habit applied were those of 8.7 mag. or brighter; those for which the reversal took place fainter ones, down to 9.7 mag., and observed by taking very special precautions, such as keeping the room dark and writing the times on a sheet of paper under a heavy black framework so that the eye was kept as nearly at rest as possible.

Another form of personal equation (discovered by Dr. Gill) is that caused by opposite direction of motion to that which is familiar. It is very sensible in eye and ear work, and seems there to be due to the observer's somewhat imperfect fractioning of the seconds. This was apparently first noted by Professor Benjamin Peirce and is mentioned in *Charvenet's Spherical and Practical Astronomy*. This form of equation has been pretty thoroughly tested by the Greenwich observers since 1885 and found trifling for polar stars and still less important for time-stars chronographically registered. The experiments for time-stars are summarised in Professor Turner's paper in the *Monthly Notices*, vol. xlviii. p. 14.

This form of personal equation in chronographic observations of time-stars seems to be indicated by the differences which Professor Küstner and Mr. R. H. Tucker find between stars observed north and those observed south of the zenith. The former are delayed in registration by $0^s.02$ or $0^s.03$ as compared with the latter.

The personal equations depending on magnitude can be best and most easily studied by observing relative right ascensions of stars in loose clusters which have been micrometrically measured either heliometrically or from their photographs. Examples of such clusters are the *Pleiades*, *Praesepe* and the cluster in *Coma Berenices* lately measured by Dr. Chase with the Yale heliometer. *Praesepe* has been especially well studied by Professor Schur, now Gauss's successor at Göttingen.

It will be seen from what precedes that in the first place the general theory of Bessel as to personal equation is confirmed, and that the same is true with regard to Wundt's explanation of the eye and ear process. Moreover, the eye and ear method is shown to give results capable of employment as nearly accurate on the average. And Wundt's comparison of chronographic registration with the psychological experiments on "simple reaction" is also shown to be justified by the fact that the time required for chronographic registration by the "muscular" method is about the same as that taken up by the shortened or rapid reactions obtained by the same method.

Astronomers need to pursue the subject into more detail, especially in the line of transit observations of stars in loose clusters, comparing them with micrometrical measurements. And there should also be more inquiry into the laws of that portion of the subject which I have called "polar equation," an inquiry which is greatly facilitated by the introduction at Greenwich of the new manner of galvanic registration of the transits of standard stars employed to determine instrumental azimuths.

In his *Grundzüge der physiologischen Psychologie* (3rd. edition : Leipzig, 1887), Professor Wundt ascribes the early experiments, which he describes as "Complicationsversuche," to the impulse of Bessel's discovery of personal equation, and his later "Reactionsversuche" to the experiments made to eliminate personal equations in longitude operations. Thus we see that the riddles which Bessel brought forward, but did not completely solve, have given rise to, and have been greatly helped towards, a more complete solution by the rise of a new branch of science—experimental psychology—which is now pursued in many of the most prominent universities of the world as a new department of study, and it is now possible to combine in a certain degree the study of the human mind with that of the physical universe, and thus to contribute towards the restoration of the unity of philosophical study.

The Spectrum of β Lyræ, as observed at Stonyhurst College Observatory in 1895. By the Rev. Walter Sidgreaves, S.J.

The collection of photographic spectra of β Lyræ, obtained with the light-power of the Perry memorial objective, consists of over 100 plates. The series was commenced in the early part of May and finished in October. During these months all other night work was considered of secondary importance. Particular attention was given to the night preceding the chief minimum, and we have thirteen plates belonging to the last day of the period, or within twenty-two hours of the minimum. Three of these cover the minimum passage and belong both to the last and to the first day of the period.

It was at first intended to make use of only three plates for each of the thirteen days, as mentioned in our report of the Observatory in the *Monthly Notices* of 1896 February. But as the micrometer work upon the plates progressed, it became evident that nearly all the plates should be used; for it was found that some details were seen on plates noted as inferior, better than on other more perfect-looking photographs. The total number of plates carefully examined is eighty-six. Some of these will be found to occupy two places in the appended catalogues of wavelengths. In these cases half of the trailed spectrum belongs to one, and half to the following day of the light period, the whole trail being long enough to represent two separate exposures.

The slitless spectrograph employed for the series has been already fully described, partly in the *Memoirs*, vol. li, and partly in the *Monthly Notices*, vol. lvi. It is the spectrograph which was used for the *Nova* of 1892, with the alteration mentioned in the report of 1896 February. Great attention was given to this alteration, and we are largely indebted to Mr. Hilger for the expeditious way in which he helped the successive steps by which we finally arrived at the true configuration and relative densities of the component glasses for bringing the rays between D and H parallel on to the prism.

The greater stability of the instrument, owing to this alteration, has proved to be a great gain. The concave collimator having to take the cone of light before it arrives at the focal plane of the object glass, we have, in place of a long appendage to the eye end of the telescope tube, a short compact spectrograph fitted into a massive metal holder firmly screwed up in the position of an ordinary eye-piece. Its behaviour in different positions of the telescope is shown by the following scale readings for the prominent lines in the bright stars:—

	Arcturus. Mm.	α Persei. Mm.	Capella. Mm.
D	84.65	84.66	84.65
F	79.55	79.55	79.55
G'	74.63	74.63	74.63
<i>h</i>	71.26	71.26	71.26
H	68.86	68.88	68.86

This appears to be as accurate as can be expected in so short a length as 15.8 mm. from D to H.

The first measurements were nearly complete at the end of 1895, but the full discussion of the series, allowing for considerable and unavoidable interruptions, has occupied a much longer time than was anticipated.

At the commencement of the work an attempt was made to show every detail of each plate on square ruled paper, and the result from fourteen plates charted in this way was an average of sixty groups of lines. But the greater number of these were too feeble to give any hope of tracing their variations with reliable accuracy; and it was decided to confine our attention to the more prominent ones. Thirteen groups were then selected for careful measurement, and the rest were left to the general remarks of the observer.

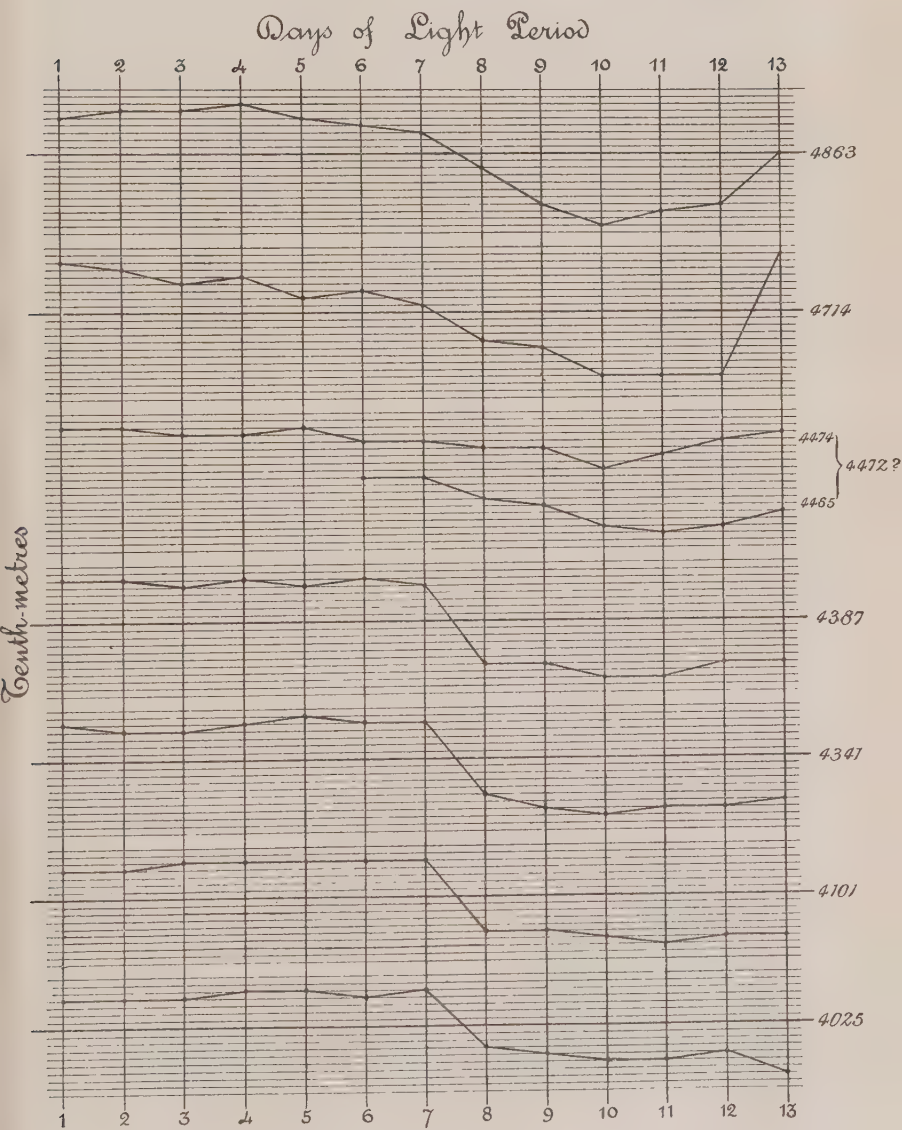
An inspection of the tables of figures will show that everything has been entered to enable the reader to form his own conclusions about the final table of mean wave-lengths, and the accompanying map of the selected lines for each day of the period. The plates are entered in the order of their time intervals from the preceding chief minimum, and their absolute dates are written in the last column, together with a note of their photographic excellence, *g.* meaning good, and *v.* very. The figures are tenth metres, and the small letters written over them* note the degree of uncertainty about them. A dash, in place of a number, explained at the foot of the table as inconclusive, means that the condition of the line, owing to a local weakness or blemish on the plate, could not be certified. It should further be observed, with reference to the note "probable," that the lines marked thus may be prudently accepted as certain: the distinction between a certain and a probable line being that the latter admits, of itself, the interpretation of contrast-effect, and is decided by its appearance on other plates in which this interpretation is inadmissible.

All the positions quoted in the tables and on the map are relative to that of the absorption component of H_{γ} , which has been adopted for the fiducial point of the curve-scale, at λ 4340. On the light-period map are shown only those lines whose changes could be followed with certainty. The complete spectrum of the star is given in addition as obtained from two selected plates, one near the primary, the other near the secondary minimum.

* *p.* for probable, and *s.* for suspected.

10m 7h 25m 1

1 2 3 4 5 6 7 8 9 10



The table of mean wave-lengths for each day shows considerable changes in the positions of the radiation lines, faithfully following the light period, while the absorption lines remain quite constant; and these mean positions are found to suffer nothing when the tables of details (pp. 522-9) are consulted. These show even more clearly that the positions of all the lines throughout the spectrum remain practically constant during the first four days after the chief minimum. On the fifth and sixth days there is a suspicion of change setting in, which becomes quite pronounced on the seventh day. The radiation lines are shifting towards the violet end of the spectrum and crossing their mean position shortly after the second minimum. On the eighth and ninth days, the wave-lengths are rapidly shortening, and reach their lowest measures on the tenth day, which is that of the second maximum. These changes are shown on the map (Plate 16)* in striking contrast with the fixed positions of the absorption lines.

The changes of the bright lines are further plotted from day to day of the light period in Plate 17, and the unsmoothed curves show, in addition to a general uniformity of all the lines, some noteworthy differences. The more abrupt shortenings of the four smaller wave-lengths between the seventh and eighth days, may be due to a greater width of these lines, which would have the effect of increasing the difference between the apparent and real centres of the lines; a difference which would be greatest at this phase of the curve when the bright line was beginning to appear on the violet side of its overlapping dark companion. The effect of superposition in concealing the real centre of the bright line has been studied by Belopolsky in H_{β} , and by Vogel in H_{ζ} ; and both observers have come to the same conclusion—that the apparent doubling of the bright lines is to be attributed to the dark line cutting out the centre of the bright line; and that when the bright line is seen only on one side of the dark line, its apparent centre cannot be accepted for the true position of the line in an estimate of radial velocity; and the real centre cannot be ascertained because a constant width of the line is an inadmissible postulate.

If we could have plotted the real centres of these bright lines, the curves would have exhibited a much closer agreement with Professor Vogel's conclusion, that "only small changes, undoubtedly standing in a certain relation to the periodic variations of the star, can be observed in the relative positions of the bright and dark lines."† The curve for line 447 is an illustration of this effect. If the red side bright line‡ had faded out when that at the violet side§ began to appear, the curve would have been of the same steep form as the rest. This consideration suggested the probability that the pair of bright lines in the latter half of the light period might be parts of the same radiation; the position of

* See also pp. 530-1.

† A and A-P, 1894 May, p. 362.

‡ The radiation of group 4.

§ The radiation of group 5.

its true centre for each day would be given by the mean of the pair of figures for that day ; and if we could, in a similar manner, point the true centres of the line in the first half of the period, the curve would be nearly of the form plotted for λ 4474, and the resulting indication of change of radial velocities would become comparatively small. This account of the pair of bright lines is in accord with Mr. McClean's recent explanation, that "the curious effect of displacement and doubling seen in the Helium line at w.l. 4472 appears to be due to the alternate obscuration of this line and the adjacent iron (?) line at w.l. 4482, by the shift of the corresponding diffuse emission Helium line at w.l. 4472" ; * but we have no division of the bright line by the dark line 448 shown on our plates. It is more closely the same as Belopolsky's explanation of $H_{\beta}^{\dagger}$, and Vogel's H_{ζ} , &c. ; and it seems to point out the treatment of the other radiations, needed for trimming our curves to a satisfactory uniformity. The steep slopes would then disappear, and the extreme differences would be reduced to comparatively small changes.

With this explanation the groups 4 and 5 should be altered : the dark line 448 of group 4 should stand by itself, and group 5 should contain the remaining three columns.

Of the other groups $\ddagger$ the following remarks from the observer's note-book are a necessary supplement to the columns of relative wave-lengths, which contain only the line or lines which could be followed safely with the micrometer.

Group 1 at λ 492.—Only one line, a dark one, of this group is entered in the tables. It has probably a bright companion on its red side, apparently always in the same position, and if it be a real line it differs from all the other radiations in keeping the same relative position as the absorption lines.

The group falls very near the red side limit of photographic sensibility, and required very careful attention. The absorption line is broad, nearly 5 tenth-metres in width. That it fades gradually during the first four days, and recovers in the last three, rests upon the percentage of certain, probable, and suspected positions for each day ; and its weakness between days 5 and 10 inclusive is shown by its complete absence from twenty-eight out of thirty-three plates belonging to this interval : of the five exceptions only two show it as probable on July 6 and September 25 ; the remaining three are barely suspected.

It is possible that these exceptions may be due to some period of longer duration than that of the light changes ; but it can hardly be doubted that the intensity of the absorption is mainly

* *M.N.* vol. lvii, p. 7.

$\dagger$ *Mélanges Mathématiques et Astronomiques*, vol. vii. p. 427.

$\ddagger$ In the original MS. the order of decreasing wave-lengths of the spectral lines was observed, both in the tables of figures and on the maps. It was decided to reverse the maps and the columns of figures for the press. But it was too late to re-arrange the text ; and for this reason the numbers of the columns appear in the reverse order, from right to left.

under some influence closely connected with the light period ; and we have, so far, no clue to any longer period : for neither of the months, July or September, can be accepted as epochs of such a period, since of the twelve plates obtained in July and twenty-five in September there are no confirmations of the positive probable exceptions.

The radiation companion is also broad like the absorption, and appears to follow the same changes of intensity, inasmuch as it is noted only for the days of the first and last quarter of the period.

Group 2 at λ 486.—Of this group only bright H_{β} is shown. It is broad and strong, with a fluctuating intensity, which may, at this part of the spectrum, be a photographic difficulty, but appearing strongest at the chief minimum. It is terminated on each side by a weak though broad absorption line ; and of the two absorptions the blue side one is the stronger during the first half of the light period, and is strongest at the first maximum, while the other on the red side is stronger in the second half and strongest at the second maximum. This looks like the reverse of Belopolsky's observations of the same line. Here we seem to have a broader absorption cut in two by a less broad radiation, the two dark components alternately both widening and strengthening as the bright line shifts to the opposite side. But this interpretation can hardly be admitted, because on two plates between the chief minimum and first maximum we have the bright line noted as divided, with the red side component the narrower and weaker on August 22 and September 30, and two plates just after the first maximum on June 20 show a probable double with equal components.

Group 3 at λ 471.—The absorption line of this group appears clearly at the chief minimum, beginning, it would seem, at eight hours before and vanishing at the end of the second day after it. It is absent on all the intervening days if we may neglect its positions entered λ 470 as more probably belonging to another origin. It may be completely masked by the bright line during this interval, and only appear when the bright line is at its greatest red-side displacement. The bright line is notably wider with diffuse and hazy edges, shortly after the second minimum, when the two centres are together, and might be divided if the dark line were stronger. This appearance of a double bright line is noted as very probable on June 12, the ninth day of the period ; and again on September 12, the tenth day, the components in each case being nearly equal, but that at the red side slightly the narrower and weaker. So far, therefore, the superposition hypothesis suits this group, but the changes of intensity do not favour it. The bright line is extremely weak near the principal minimum, and is quite extinct at the precise hour of the minimum ; while it is strongest just after second minimum.

Groups 4 and 5.—Of these two groups, which have been

already fully discussed as one group, it is only necessary to add that both the dark components appear to spring suddenly up to their strongest either at, or shortly before, the principal minimum, agreeing with Vogel's observation * of H_{ζ} . The extreme weakness of the absorption line 448 on day 5 is very remarkable. There are four good plates for this day, one taken in May, two in September, and one in October ; and it is only barely suspected on two out of the four.

Groups 6, 12, and 13 agree with group 3 in the extreme weakness of the radiation at the first minimum, but differ in being also very weak at and after the second minimum. But they show no signs of widening or dividing.

Group 7.—Both the radiation and absorption components of H_{γ} are very strong between the chief minimum and first maximum. The absorption is weaker during the second half of the period, and is very feeble at both minima. A weaker absorption on the red side of the hydrogen pair remains nearly constant throughout the period.

The radiation is nearly, if not quite, extinct at both minima. Its brightness fades continuously between the preceding maximum and the minimum phases, and recovers abruptly shortly after each minimum. These variations are in striking contrast with the comparatively constant radiation intensity of H_{β} . A careful re-examination of the best plates shows that this discordance between the two hydrogen lines cannot be attributed to the difference between the photographic sensibility at the two parts of the spectrum ; there is no appearance of over-exposure at the position of H_{γ} .

Group 8 at λ 423.—This absorption line, like that at λ 448, is quite extinct on day 5. No trace of it is found on the same four plates already quoted for the line 448 of group 4. A feeble radiation line has also been noted as probable or suspected on some of the plates belonging to the period from just before the first minimum to the first maximum, always on the red side of the absorption.

Group 9.—This appears always as a single absorption line, except on July 27, second day after first minimum, when there is probably a radiation companion on the red side ; and on two plates of June 30, just after first minimum, it appears unusually wide and probably divided.

Group 10.—A radiation line is noted as probable on the red side of this dark line on June 30 only, just after chief minimum. The absorption line has been noted as probably double on the following days :

Day 2, June 5.

„ 2, July 1, on two plates. Red side component wider.

„ 4, June 20. Both components equal.

* A and A-P, 125, p. 363.

- Day 4, July 3. Red side component narrower.
 „ 5, Sept. 20. „ „ „ „
 „ 13, July 12. Blue side component very narrow and weak.

To conclude, we may ask and endeavour to answer the question : what has been added to our knowledge of this variable star since our first attempts upon its spectrum with the weaker light-power in 1893? If we confine our attention to our own observations the answer is ready, that we have neither more nor less than a confirmation of the conclusions stated in our report of the earlier work,* including the suggestion of tidal action as the cause of the bright line origins, and the claims for an elongated ellipse in place of a circular orbit. The exceptional absences of lines from plates which ought to show them if existent, at times when they usually appear, may be accounted for by the complex movements of more than two stars. They are more easily explained by the natural variations attending the periodic evolution of heat by tidal action at the periastron. The abrupt changes, both of intensity and position, at the chief minimum as compared with the slower changes at the secondary minimum are very significant ; the velocity at the first must be greatly in excess of that at the second minimum, which is inconsistent with circular motion. The constancy of the spectrum, both in the strength and position of the lines, during the first quarter of the period beginning at the middle of the first day indicates, on the one hand, the first days of renewed heat energy, and, on the other, a sharp curve in the orbit at periastron, and the general weakness of the radiation lines in the latter half of the period is more in keeping with the cooling process of the bright line star than with the shading of superpositions. This view of the state of things with β *Lyræ* is at least not opposed to Belopolsky's conclusion : “En général il faut avouer que l'ensemble des faits, que l'on observe dans le spectre de cette étoile, est loin d'être expliqué par un mouvement des corps sur des orbites ; il faudra toujours dans l'explication revenir aux procédés intérieurs.”†

* *M.N.* vol. liv. pp. 98-99.

† *Mélanges Mathématiques et Astronomiques*, vol. vii. p. 446.

Wave-lengths and Intensities of Selected Groups in the Spectrum of β Lyrae

Day Age from Principal Minimum.	d. h.	13				12				11		10		9		8		7			
		Rad.		Abs.		Rad.		Abs.		Abs.	Abs.	Abs.	Abs.	Abs.	Abs.	Rad.		Abs.			
		λ	i	λ	i	λ	i	λ	i	λ	i	λ	i	λ	i	λ	i	λ	i		
		40		40		41		41		41		41		41		42		43		43	
1	0 0			26 6				02 6	21 2	30 3	46 4	35 2							40 3		
	0 0			26 4				03 5	21 2	30 3	45 4	35 3							40 2		
	0 2			26 6				02 5	22 2	30 3	45 5	35 3	46 3	40 3							
	0 11	-	-	25 6	s	-	01 8	21 2	31 3	44 3	35 3	47 10	40 4								
	0 12	-	-	25 10	s	-	01 10	20 2	30 4	43 4	36 2	46 8	40 10								
	0 22	29 4	25 10	05P 4	01 10	21 5	30 5	43 9	35 4	46 10	40 10										
Means ...		29	1	26 7	05P 1	02 7	21 3	30 4	44 5	35 3	46 5	40 5									
2	1 8	-	-	26 6	-	-	01 10	21 3	30 4	44 4	34 2	46 8	40 10								
	1 9	30P 2	26 10	06P 2	02 10	22 2	31 3	44 3	35P 2	46 6	40 10										
	1 9	-	-	26 8	-	-	02 10	21 2	31 4	45 4	34 2	45 3	40 10								
	1 12	-	-	26 6	s	-	02 10	22 2	30 3	45 3	35 2	45 8	40 10								
	1 12	-	-	26 10	s	-	01 10	22 3	31 4	44 4	34 3	45 6	40 10								
	1 15	29P 2	25 9	05S -	01 10	20 3	29 4	44 6	34 3	46 8	40 10										
	1 18	29P 3	25 6	05P 2	00 10	20 3	29 4	44 5	33 4	45 10	40 10										
	1 22	29P 2	26 8	05P 2	01 10	21 2	30 3	43 4	33 2	45 8	40 8										
	1 23	29P 3	25 10	05P 2	01 10	20 2	30 3	43 4	34 2	45 8	40 9										
Means ...		29P 2	26 8	05P 2	01 10	21 2	30 4	44 4	34 2	45 7	40 10										
3	2 3	30S -	25 6	06S -	01 10	21 2	30 3	44 4	33 2	45 10	40 10										
	2 5	30S -	26 6	05S -	01 10	20 2	29 3	43 4	35 1	46 10	40 7										
	2 7	30S -	26 5	05S -	01 10	20 2	30 3	44 3	35 2	45 8	40 6										
	2 8	29S -	25 6	05S -	01 10	20 2	30 3	43 3	33 1	45 10	40 6										
	2 8	-	-	26 6	06S -	02 10	21 2	30 1	43 2	35 2	46 10	40 5									
	2 9	30S -	26 6	06P 2	01 10	20 2	30 3	44 3	35 2	46 10	40 6										
	2 10	29P 2	26 5	06S -	01 10	20 2	30 2	44 3	35 2	45 8	40										
Means ...		29P 2	26 6	06P 2	01 10	20 2	30 3	44 3	34 2	45 9	40 7										
		40		40		41		41		41		42		43		43					

s = suspected
Dash = inconclusive } Excluded from means.
i = intensity, 10 = the maximum.

from a series of Photographs obtained at Stonyhurst College Observatory.

6		5		4		3		2	1	Date, &c. 1895.
Rad. λ μ	Abs. λ μ	Rad. λ μ	Abs. λ μ	Rad. λ μ	Abs. λ μ	Rad. λ μ	Abs. λ μ	Rad. λ μ	Abs. λ μ	
43	43	44	44	44	44	47	47	48	49	m. d. h.
	88 5		69 4	75 6	80 4		15 1	68 10	23 4	9 15 11 $\frac{3}{4}$, v.g.
	89 6		71 3	77 4	81 3	09s -	- -	68 10	26 4	9 28 10 "
	88 9		69 5	75 5	80 5		13 4	65 10	- -	10 24 8 "
s -	88 6		70 8	77 10	82 3	- -	13 4	69 8	24 2	6 30 10-50 "
93s-	88 10		71 10	76 8	81 4	- -	13 4	71 8	24 3	6 30 11-45 "
93P2	88 10		70 10	76 10	80 4	21 3	13 4	69 10	26 9	9 29 8, perfect
93P1	88 8		70 7	76 7	81 4	21 1	13 3	68 9	25 4	
92s-	87 9		69 10	75 10	78 4	19P 2	13 4	68 6	26 3	6 5 11 $\frac{3}{4}$, fair
93P2	87 8		70 8	76 10	81 3	21 4	13 4	71 6	- -	6 5 12 $\frac{1}{2}$ "
92s-	88 5		69 4	75 6	79 4		12 2	69 4	27P2	6 18 11, g.
92s-	88 5		70 6	76 10	79 4	18P 2	13 1	69 2	24P2	7 1 12 "
91s-	87 4		70 6	75 10	79 2	19s -	13s-	69 2	24s-	7 1 12 "
94 5	88 6		70 7	76 10	80 3	21P 2	15s-	71 3	26 3	7 27 11 "
93 3	88 6		69 6	76 10	80 3	21P 2	15P2	71 6	26 4	8 22 10, v.g.
92P2	87 4		69 5	75 6	78P2	21 3	- -	68 6	23 4	9 30 8, g.
93s-	88 4		70 4	76 10	78P2	22 2	15 2	69 8	26 4	9 30 9, v.g.
93 3	88 6		70 6	79 3	76 9	20 2	14 3	69 5	25 3	
92P2	87 4		69 4	75 10	78P2	18 2	13 2	68 6	23 3	10 26 9, v.g.
92s-	87 4		69 3	76 10	78s-	21s -		69 6	23 3	5 11 13 "
93s-	88 3		70 3	75 10	78s-	17 6		69 4	24s-	6 6 11 "
92s-	86 3		69 3	75 6	78s-	- - - -		68 4		6 6 11 $\frac{1}{2}$, g.
92P2	88 3		70 3	75 10	80s-	s - - -		69 10	23s-	6 6 11 $\frac{1}{2}$, poor
93P2	88 3		70 3	76 10	78s-	19P 2		69 6	- -	6 19 11, fair
92P2	88 3		70 3	75 10	78s-	19 4		71 4	- -	6 19 11 $\frac{1}{2}$, g.
92P2	87 3		70 3	75 9	78P2	18 4		69 6	23 2	
43	43	44	44	44	44	47	47	48	49	

P = probable.
Blank = no line.

Day Age from Principal Minimum.	13				12				11		10		9		8		7			
	Rad.		Abs.		Rad.		Abs.		Abs.		Abs.		Abs.		Abs.		Rad.		Abs.	
d. h.	λ	i	λ	i	λ	i	λ	i	λ	i	λ	i	λ	i	λ	i	λ	i	λ	i
4	3 7	29s	—	25 6	4I	s	—	0I 10	20 2	30 2	4I	30 2	44 3	42	s	—	46 10	40 10	43	43
	3 8	29s	—	25 4	05 10	0I 10	0I 10	20 2	28 3	42 4	s	—	46 10	40 6			46 10	40 6		
	3 9	30	5	26 6	06 4	0I 10	20 2	30 3	43 3	35P 2	46 10	40 7					46 10	40 7		
	3 11	s	—	26 5	06P 2	0I 10	20 2	30 4	43 4	34 2	46 6	40 10					46 6	40 5		
	3 12	30s	—	25 5	s	—	02 10	20 2	29 3	43 3	s	—	46 6	40 5			46 6	40 5		
	3 15	30s	—	25 6	06P 2	0I 10	20 2	30 3	43 3	33s	—	46 8	40 10				46 8	40 10		
	3 17	30	4	26 4	06 4	0I 10	21 2	30 2	43 2	35 1	47 6	40 7					47 6	40 7		
Means ...	30	5	25 5	06 4	0I 10	20 2	30 3	43 3	35 2	46 8	40 8									
5	4 6	30s	—	25 6	06 2	0I 10	21 2	31 3	43 4								46 8	40 7		
	4 20	30s	—	26 5	06 6	0I 10	20 2	30 3	44 3								47 10	40 8		
	4 20	30P 2	27 4	07 2	02 8	20 2	30 2	44 2									48 6	40 4		
	4 23	29P 2	25 4	06 3	0I 8	20 2	30 3	43 3									45 6	40 5		
Means ...	30P 2	26 5	06 3	0I 9	20 2	30 3	44 3										47 8	40 6		
6	5 2		26 5		03 9	21 2	31 2	44 2	34 2	45 6	40 4									
	5 11		26 5		0I 9	20 2	30 3	44 3	34s	—	45 6	40 4								
	5 18	—	25 2	s	—	0I	—	—	—	—	—	—	—	—	—	—	46 4	40 4		
	5 21	29P 2	26 5	06s	—	02 10	21 2	30 4	44 3	34 3	46 6	40 5								
	6 0	30s	—	26 3	06s	—	0I 8	21 2	30 3	44 3	33 2	47 7	40 3							
Means ...	29P 1	26 4		02 9	21 2	30 3	44 3	34 2	46 6	40 4										
7	6 0	30s	—	26 3	06s	—	0I 8	21 2	30 3	44 3	33 2	47 7	40 3							
	6 4	30s	—	26 4	06s	—	02 10	21 2	31 3	44 3	33 2	46 3	40 4							
	6 11	—	25 3	—	—	02 6	20 2	30 2	44 2	34P 2	45 2	40 2								
	6 12		25 2			0I 2	20 2	30 2	43 2	—	—	46P 2	40 3							
	6 12	30P 2	26 4			03 6	22 2	31 3	45 3	35 2	46s	—	40 3							
	6 20		25 2			00 6	20 2	30 2	43 2	—	—	40s	—							
Means ...	30P 1	26 3		02 6	21 2	30 3	44 3	34 2	46 3	40 3										
	40	40	4I	4I	4I	4I	4I	4I	42	43	43									

s = suspected
 Dash = inconclusive } Excluded from means.

May 1897.

as observed at Stonyhurst.

525

6		5		4		3		2	1	Date, &c. 1895.
Rad. λ i	Abs. λ i	Rad. λ i	Abs. λ i	Rad. λ i	Abs. λ i	Rad. λ i	Abs. λ i	Rad. λ i	Abs. λ i	
43	43	44	44	44	44	47	47	48	49	m. d. h.
93 6	87 3		71P 2	75 10	79s-	19 5		69 6	24 3	6 7 11 $\frac{1}{4}$, g.
93P2	87 3		70s -	75 10	78s-	18 4		68 8	24 2	6 7 12 ,,
94s-	88 3		71s -	75 10	79s-	- -		69 8	- -	6 20 10 $\frac{1}{2}$, fair
93P2	87 3		70P 2	75 10	79P2	16s -		71 5	26 3	7 3 10-40, g.
92s-	87 2		s -	75 8	- -	- -		71 5	- -	7 3 11-40 ,,
92P2	87 3		70 3	76 8	79 2			71 6	23 2	7 29 10 $\frac{1}{2}$,,
92P2	87 3		70s -	76 6	79s-	19 3		69 5	24P2	8 24 9 ,,
93 3	87 3		70 2	75 9	79 2	19 3		70 6	24 2	
93s-	86P 2		71s -	76 6	80s-	17 4		69 6		5 26 12, g.
92 6	87 4		71s -	76 10	79s-	18 6		69 10		9 20 8 ,,
s-	87 2			76 10		16 6		68 10		9 7 10 ,,
92P2	85 2			74 10		14 4		65 6		10 16 7 ,,
92 4	86 3			76 9		16 5		68 8		
93 3	88 2	s -		74 10		16 5		67 8		5 1 13, v. g.
94s-	88 2	71 6		75 10	80P2	17 5		69 6		7 5 10-35, v. g.
- -	- -	69 8		74 9	- -	17 4		67 3	- -	9 8 8, v. poor
94P2	88 3	69 7		75 10	80 3	17 6		68 10		10 4 7-25, v. g.
92 3	86 2	67 6		74 10	s-	16 6		65 10		10 17 8 ,,
93 3	88 2	69 7		74 10	80 2	17 5		67 7		
92 3	86 2	67 6		74 10	s-	16 6		65 10		10 17 8, v. g.
90s-	87 2	68s -		74 10	80 2	16 2		67 4		5 15 11 $\frac{3}{4}$,,
	87 1	72 10		76 10	80 2	16 6		68 3	- -	7 6 11, poor
93s-	88 2	68 10		74 10	79 2	17 5		67 4	23P2	7 6 12, fair
93s-	88 2	69 10		75 10	s-	16 3		67 8		7 19 10-25, g.
	86s -	67 10		73 10	78 2	10 2		62 9		9 22 8, g.
92 1	87 2	69 9		74 10	79 2	15 4		66 6		
43	43	44	44	44	44	47	47	48	49	

P = probable.
Blank = no line.

Day Age from Principal Minimum.	d. h.	13				12				11		10		9		8		7			
		Rad.		Abs.		Rad.		Abs.		Abs.		Abs.		Abs.		Abs.		Rad.		Abs.	
		λ	i	λ	i	λ	i	λ	i	λ	i	λ	i	λ	i	λ	i	λ	i	λ	i
		40		40		40		41		41		41		41		42		43		43	
8	7 7			26	5			02	8	21	2	30	4	45	4	33	2	36s	-	40	3
	7 8	-	-	26	3	-	-	02	10	22	2	30	4	45	2	s	-	36	-	40	4
	7 9	-	-	26	2	-	-	02	8	21	2	30	5	45	2			36s	-	40	4
	7 11	-	-	26	3	-	-	02	4	20	2	30	2	45	2	35	2	36s	-	40	3
	7 12	-	-	25	4	-	-	01	6	20	2	29	3	44	3	33	2	s	-	40	3
	7 15	-	-	25	4	-	-	01	10	22	2	30	4	44	4	35	3	36P	2	40	6
	7 18	21	-	26	3	97s	-	02	8	22	2	30	3	44	3	34	2	36	4	40	4
	7 21	22P	2	26	3	96P	2	01	4	21	2	30	3	44	2	34	2	36s	-	40	2
	7 23	-	-	27	4	98s	-	03	10	23	2	32	3	45	3	35	2	36	5	40	5
Means ...		22P	1	26	3	96P	1	02	8	21	2	30	3	45	3	34	2	36	4	40	4
9	8 8	-	-	26	4			02	8	20	2	30	3	45	3	35	2	35	2	40	4
	8 11	-	-	-	-	96s	-	01	4	20	2	30	2	43	2	33P	2	35P	2	40	5
	8 14	21s	-	25	4	96s	-	01	10	21	2	30	4	43	3	33	2	33	2	40	3
Means ...				26	4			01	7	20	2	30	3	44	3	34	2	34	2	40	4
10	9 3	-	-	26	4	s	-	01	6	20	2	29	3	43	2	s	-	34	2	40	4
	9 19	-	-	-	-	-	-	01	10	21	2	30	2	43	2	33	2	33	2	40	4
	9 20	20s	-	25	2	95s	-	01	10	19	2	30	3	44	3	34	2	33	5	40	6
	9 21	20s	-	25	4	95s	-	01	8	21	2	29	2	43	2	33	2	33	3	40	4
	9 21	20P	2	25	2	96s	-	01	10	21	2	30	3	44	3	33	2	34	3	40	5
	9 23	21s	-	27	3	94s	-	02	8	21	2	31	2	43	2	34	2	33	3	40	4
Means ...		20P	2	26	3			01	9	21	2	30	3	43	2	33	2	33	3	40	5
11	10 9	19s	-	25	4	94s	-	01	10	20	2	31	2	44	2	35P	2	33P	2	40	8
	10 18	19	2	24	4	94P	2	01	7	21	2	29	3	43	3	s	-	33P	2	40	4
	10 21	19s	-	25	4	96s	-	01	8	20	2	30	2	43	2			34	3	40	8
	10 22	21P	2	25	6	95s	-	01	8	20	2	30	2	44	2	33P	2	35	2	40	5
	10 23	-	-	-	-	-	-	03	6	21	2	30	2	44	2	s	-	34s	-	40	4
	10 23	-	-	25	3	-	-	03	10	22	2	31	2	45	2	34	2	36	2	40	7
Means ...		20P	2	25	4	94P	2	02	8	21	2	30	2	44	2	34P	2	34	2	40	6
		40		40		40		41		41		41		41		42		43		43	

s = suspected
 Dash = inconclusive } Excluded from means.

May 1897.

as observed at Stonyhurst.

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6		5		4		3		2	1	Dat., &c. 1895.
Rad. λ	Abs. λ	Rad. λ	Abs. λ	Rad. λ	Abs. λ	Rad. λ	Abs. λ	Rad. λ	Abs. λ	
13	43	44	44	44	44	47	47	48	49	m. d. h.
	87 ^P 2	66 10		72 10	78 3	06 6		58 9	s -	6 11 11, g.
s -	87 2	66 10		73 10	78 3	09 6		58 10		6 11 12 „
s -	88 2	67 10		74 10	79 2	11 6		62 6		6 24 11, fair
	87 2	68 10		74 10	79 2	11 5		62 8		7 7 10-35, g.
	85 2	66 10		73 10	78 2	09 4		60 9		7 7 12, g.
	87 2	66 6		74 6	79 3	09 4	01 ^P 2	61 6		8 11 1 „
	87 2	67 9		74 9	79 3	12 5	05 ^s -	62 8		9 10 8, v. g.
	87 2	65 8		73 8	79 2	12 4		60 10		9 23 9 „
81s-	88 2	66 10		73 10	80 2	13 6		62 9		10 19 7 „
	87 2	66 9		73 9	79 2	10 5		61 8		
s -	87 2	66 5		73 5	79 2	10 5		55 6		6 12 11 ³ / ₄ , v. g.
81s-	86 2	64 5		73 5	78 3	11 4		55 4		6 25 13, poor
	86 2	66 3		73 3	78 2	06 4	00 2	58 4		7 21 12, fair
	86 2	65 4		73 4	78 2	09 4		56 5		
s -	87 1	62 2		71 2	77 2	06 3		50 5		5 18 11 ¹ / ₄ , g.
79s-	86 2	62 5		68 5	77 4	05 3	46 97 ^P 2	53 4		9 12 9, g.
80s-	86 2	62 4		70 4	78 2	06 3	98 ^P 2	54 10	s -	9 25 8, v. g.
79s-	86 2	61 5		69 5	78 2	05 5	97 ^P 2	53 10		9 12 11, g.
79s-	85 3	60 4		70 4	77 3	01 2	s -	55 6	24 ^P 2	9 25 9, v. g.
79s-	86 2	62 2		71 2	77 2	04 2		53 6		10 8 9, g.
	86 2	62 4		70 4	77 3	05 3		53 7	24 ^P 1	
79 ^P 2	87 4	63 ^P 3	67s -	74s -	78s -	04s -		54 6	- -	6 27 10 ¹ / ₂ , v. g.
79 ^P 2	85 3	60 4	64 2	69 4	76 2	04 4	97s-	53 10	20 ^P 2	9 13 8 „
81s-	86 3	61 3	67 ^P 2	73 3	78 ^P 2	05s -		55 4	26 ^P 2	9 13 11 „
78s-	85 2	61 2	66 2	72 2	77 2			57 4	24s-	9 26 10, g.
s -	87 2	- -	68s -	s -	79 2	- -		57 4	29 ^P 2	9 26 11 „
	86 3	62 ^P 2	67 3	72 ^P 2	78 3	05 3		54 5	23 ^P 2	10 22 7, v. g.
79 ^P 1	86 3	61 3	66 2	72 3	78 2	05 2		55 6	25 ^P 2	
13	43	44	44	44	44	47	46	48	49	

P = probable.
Blank = no line.

LEEDS PHILOSOPHICAL
AND LITERARY SOCIETY

Day Age from Principal Minimum.	13				12				11		10		9		8		7			
	Rad.		Abs.		Rad.		Abs.		Abs.	Abs.	Abs.	Abs.	Abs.	Abs.	Abs.	Abs.	Rad.		Abs.	
	λ	μ	λ	μ	λ	μ	λ	μ	λ	μ	λ	μ	λ	μ	λ	μ	λ	μ	λ	μ
	40		40		41		41		41		41		41		42		43		43	
12	II 8		26	6			01	10	22	2	30	4	44	4	34	2	35 ^s	-	40	6
	II 8	21s -	26	4	96s -		01	8	22	2	30	3	45	3	34	2	35 ^p	2	40	5
	II 9		26	4			01	8	20	3	30	4	45	3	-	-	s	-	40	5
	II 9		26	4			01	10	20	2	29	3	43	3	33	2	31	2	40	5
	II 19		25	3			01	7	20	2	30	2	44	2	33 ^s	-			40	4
	II 20		26	4	94 ^p	2	01	6	20	2	30	2	43	2	s	-			40	3
	II 21	2Cs -	26	4	s	-	02	7	21	2	30	2	45	3	33	2			40	5
II 21	21P 2	25	5	s	-	01	10	20	2	30	3	44	3	33	2			40	4	
II 23		26	3			02	6	21	2	31	3	44	3	s	-	35 ^p	2	40	4	
Means ...		26	4			01	8	21	2	30	3	44	3	33	2	34 ^p	1	40	5	
13	12 7		25	7			01	10	20	2	30	4	43	4	33	2	34 ^s	-	40	4
	12 8		25	7			02	10	22	2	30	4	45	4	34	2	s	-	40	5
	12 10		26	5			02	8	21	2	30	3	44	3	33	2	34 ^p	2	40	3
	12 11		25	4			02	6	22	2	31	3	44	3	34	2	s	-	40	2
	12 12		25	4			02	6	21	2	30	4	45	3	34	2	s	-	40	2
	12 14	18s -	26	6	95 ^s	-	01	10	21	2	30	4	45	4	35	3	35 ^p	2	40	5
	12 17	s -	26	8	s	-	02	8	22	2	30	3	45	4	34	2			40	2
	12 19		26	5			02	6	22	2	31	3	45	3	s	-			40	2
	12 20		26	5			01	6	22	2	30	2	44	2	33	2			40	2
	12 21		27	6			02	6	22	2	32	3	45	3	35	1			40	3
0 0		26	6			02	6	21	2	30	3	46	4	35	2			40	3	
Means ...		26	6			02	7	21	2	30	3	45	3	34	2	35 ^p	1	30	3	
	40		40		41		41		41		41		41		42		43		43	

s = suspected
Dash = inconclusive } Excluded from means.

May 1897.

as observed at Stonyhurst.

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6		5		4		3		2	1	Date, &c. 1895.
Rad. λ	Abs. i	Rad. λ	Abs. i	Rad. λ	Abs. i	Rad. λ	Abs. i	Rad. λ	Abs. i	
3	43	44	44	44	44	47	46	48	49	m. d. h.
	87 3	- -	68 4	s -	78 3	s -	s -	55 2	24 2	6 15 12, g.
8IP2	86 4	63P 2	69 4	74P 2	79 2		s -	54 4	24P 2	6 15 11 $\frac{1}{2}$ „
s -	87 3		68 4		80 3	04P 2	96P 2	57 2		6 15 12 $\frac{3}{4}$ „
	87 3	- -	66 2	s -	78 2	05P 2		53 3	s -	6 15 13 $\frac{1}{4}$, v.g.
	86 3		69 4		80 3	07s -	99s -	62s -		9 27 7, g.
s -	87 3	60P 2	68 7		79 3			60 4	21PI	9 27 8 „
	87 4		69 8		79 4			58 5	21 4	9 27 9, v.g.
	86 4		68 8		79 4	s -	s -	55 5	20s -	10 10 7, g.
SOS -	86 3	62P 2	67 10	74P 2	78 3	04s -	$\left\{ \begin{smallmatrix} 97s - \\ 47 \\ 09s - \end{smallmatrix} \right\}$	54 3	23 2	10 23 7, v.g.
	87 3	62P 1	68 6	74P 1	79 3	05P 1		56 4	23 2	
79s -	85 4	63P 2	68 3	74P 2	78 3		- -	58 9	21 4	6 16 10 $\frac{1}{2}$, v.g.
s -	87 5		69 3		80 3	21P 2	s -	60 6	21 4	6 16 11 $\frac{1}{2}$ „
s -	87 4	s -	68 3	s -	79 3	22P 2	s -	60 4	23 3	7 12 10-25, v.g.
	87 3	s -	68 3	s -	79 3			61 9	21 4	7 12 10-40, g.
	87 5	s -	68 2	74P 2	79 2	s -		60 10	24 3	7 12 11-40, v.g.
82P 2	87 5	64P 2	69 5	75P 2	79 5	s -	13 3	64 9	24 4	8 7 10, v.g.
	89 6		70 3		81 3	s -	15 2	65 10	24 4	9 2 9, g.
8IP 2	88 6	64s -	70 3	76P 2	81 3		13 2	65 10	24 4	9 15 8 $\frac{3}{4}$, v.g.
8IP 2	87 5	- -	68 3	74 4	79 3	18s -	13 2	64 10	20 2	9 15 10, poor.
	89 4	64P 2	70 3	76 4	80 3		13 3	65 10	24 3	9 15 11-15, v.g.
	88 5		69 4	75 6	80 4		15 1	68 10	23 4	9 15 11 $\frac{3}{4}$ „
8IP 1	87 5	64P 1	69 3	75 2	80 3	22P 1	14 2	63 9	23 4	
3	43	44	44	44	44	47	47	48	49	

p = probable.
Blank = no line.

Spectrum of β Lyrae, 1895, Stonyhurst College Observatory. Mean

Day Age.	13				12				11		10		9		8		7		
	Rad. λ	i	Abs. λ	i	Rad. λ	i	Abs. λ	i	Abs. λ	i	Abs. λ	i	Abs. λ	i	Abs. λ	i	Rad. λ	i	Abs. λ
	40		40		41		41		41		41		41		42		43		43
1	29	1	26	7	05P	1	02	7	21	3	30	4	44	5	35	3	46	5	40
2	29P	2	26	8	05P	2	01	10	21	2	30	4	44	4	34	2	45	7	40
3	29P	2	26	6	06P	2	01	10	20	2	30	3	44	3	34	2	45	9	40
4	30	5	25	5	06	4	01	10	20	2	30	3	43	3	35	2	46	8	40
5	30P	2	26	5	06	3	01	9	20	2	30	3	44	3			47	8	40
6	29P	1	26	4			02	9	21	2	30	3	44	3	34	2	46	6	40
7	30P	1	26	3			02	6	21	2	30	3	44	3	34	2	46	3	40
8	22P	1	26	3	40		02	8	21	2	30	3	45	3	34	2	36	4	40
9			26	4	96P	1	01	7	20	2	30	3	44	3	34	2	34	2	40
10	20P	2	26	3			01	9	21	2	30	3	43	2	33	2	33	3	40
11	20P	2	25	4	94P	2	02	8	21	2	30	2	44	2	34P	2	34	2	40
12			26	4			01	8	21	2	30	3	44	3	33	2	34P	1	40
13			26	6			02	7	21	2	30	3	45	3	34	2	35P	1	40
	40		40		40		41		41		41		41		42		43		43
Range	10	4	1	5	12	3	1	4	1	1	0	2	2	3	2	1	14	8	0

Wave-lengths and Intensities of the Selected Groups for each Day Age.

6		5		4		3		2	1	No. of Plates
Rad. λ	Abs. i	Abs. λ	Rad. i	Rad. λ	Abs. i	Rad. λ	Abs. i	Rad. λ	Abs. i	
43	43	44	44	44	44	47	47	48	49	
93 ^P 1	88 8	70 7		76 7	81 4	21 1	13 3	68 9	25 4	6
93 3	88 6	70 6		76 9	79 3	20 2	14 3	69 5	25 3	9
92 ^P 2	87 3	70 3		75 9	78 ^P 2	18 4		69 6	23 2	7
93 3	87 3	70 2		75 9	79 2	19 3		70 6	24 2	7
92 4	86 3			76 9		16 5		68 8		4
93 3	88 2		69 7	74 10	80 2	17 5		67 7		5
92 1	87 2		69 9	74 10	79 2	15 4		66 6		6
	87 2		66 9	73 9	79 2	10 5		61 8		9
	86 2		65 4	73 4	78 2	09 4		56 5		4
	86 2		62 4	70 4	77 3	05 3		53 7	24 ^P 1	5
79 ^P 1	86 3	66 2	61 3	72 3	78 2	05 2		55 6	25 ^P 2	6
	87 3	68 6	62 ^P 1	74 ^P 1	79 3	05 ^P 1		56 4	23 2	9
81 ^P 1	87 5	69 3	64 ^P 1	75 2	80 3	22 ^P 1	14 2	63 9	23 4	11
43	43	44	44	44	44	47	47	48	49	
14 3	2 6	4 5	8 8	6 9	4 2	18 4	1 1	16 5	2	

On the Mean Places and Proper Motions for 1900 of 24 Southern Circumpolar Stars. By David Gill, C.B., F.R.S., Her Majesty's Astronomer at the Cape.

The following are the results of a discussion of all known accurate fundamental determinations of the places of the circumpolar stars which are employed for azimuth-determination at the Cape Observatory.

The Cordoba places are the only not strictly fundamental results which are included in the discussion.

The Cape places employed depend almost entirely upon azimuths which have been determined by observations of very close circumpolars at one or more successive transits both above and below pole. In some few cases the Cape azimuths depend on the upper transits of several very close circumpolars combined with the lower transits of others, but such determinations have only been regarded as fundamental when the places of the azimuth-determining stars can be derived from fundamental observations made near the same epoch.

The unpublished Cape results, 1861-65, have been included in the discussion.

The only systematic corrections which have been applied are those required on account of the various systems of clock-stars employed.

The reductions to 1900 were computed by the rigorous trigonometrical formulæ, and the final mean place and proper motion for each star depends upon a least square discussion.

The whole of the observations, and especially the right ascensions, are very accurately represented. Details of the discussion will be published as an appendix to the Cape General Catalogue for 1890.

Star.	Mag.	R.A. 1900's		P.M. in R.A. s	Dec. 1900's.	P.M. in Dec.
		h	m			
o Octantis	7.2	0	12 29.47	+0.006	-88 55 8.31	+0.001
Lacaille 634	5.6	1	43 7.85	+0.010	-85 16 29.14	+0.023
Lacaille 1029	7½	2	35 29.87	-0.018	-86 9 41.49	+0.001
Lacaille 1848	8.4	3	3 53.06	-0.052	-88 34 20.81	-0.030
Lacaille 1707	6.8	4	34 28.67	-0.018	-83 6 55.25	+0.015
Lacaille 2296	6.3	5	49 33.61	-0.010	-84 50 6.33	+0.086
Lacaille 2512	6.8	6	6 9.50	-0.022	-85 55 52.85	+0.004
Lacaille 3274	6.3	7	22 1.23	-0.009	-86 52 11.38	+0.007
A Octantis	7.8	7	53 1.68	-0.028	-88 34 24.92	+0.010
ξ Octantis	5.5	9	11 14.16	-0.111	-85 15 46.81	+0.045
Lacaille 4510	6.9	10	36 55.09	-0.008	-85 34 21.32	-0.018
η Octantis	6.2	11	0 0.96	-0.056	-84 3 21.36	0.000
ε Octantis	5.4	12	44 26.89	+0.035	-84 34 48.60	+0.029
κ Octantis	5.7	13	24 42.05	-0.077	-85 16 24.74	-0.018
z Octantis	6.5	14	38 59.80	-0.186	-87 44 30.65	-0.061
ρ Octantis	5.7	15	20 11.44	+0.081	-84 7 55.04	+0.082
Lacaille 6545	6.0	16	23 34.41	-0.004	-86 10 42.67	+0.014
χ Octantis	5.2	17	56 4.34	-0.114	-87 39 51.38	-0.124
σ Octantis	5.5	18	59 43.21	+0.085	-89 15 16.45	-0.005
Lacaille 8094	6.3	19	37 36.44	-0.008	-81 36 0.52	+0.007
Lacaille 8257	7.1	20	18 47.39	+0.027	-84 44 48.45	+0.030
B Octantis	6.6	21	37 38.51	-0.012	-89 19 3.12	-0.034
C Octantis	5.7	22	12 34.98	-0.043	-86 28.33.63	+0.070
τ Octantis	5.6	23	13 9.48	+0.018	-88 1 52.85	+0.010

Royal Observatory, Cape of Good Hope :
1897 April 5.

New Double Stars found at the Cape Observatory in 1896.

(Communicated by D. Gill, C.B., LL.D., &c., H.M. Astronomer.)

The new double stars contained in the first of the two following lists have been found by Mr. R. T. A. Innes with the 7-inch equatorial of this observatory. They are numbered in continuation of his lists in the *Monthly Notices*, March 1895, vol. lv., and the *Journal of the B.A. Association*, April 1896, vol. vi. As the clock of the telescope is not sufficiently good for measuring, the angles and distances are estimated only. The second list contains stars found by the observers at the transit circle.

The magnitudes are taken from the different Cordoba determinations in nearly every case.

The mean date of observation may be taken as 1896.6.

No.	Star.	Mag.	R.A. h m s	1900. S. Dec.	Estimated. p. Δ.	Mags.	Notes.
43	Lac. 9755	6.9	0 5 44	73 47.0	340 0.8	7.3-8.3	Physical system. P.M. = 0".13, 9".1.
44	Lac. 95	7.6	23 27 55	10.6	250 0.75	7.9-9.1	Lac. 102, mag. 7.3, is about 14' N.f.
45	Lac. 130	6.9	28 49 55	52.8	280 0.8	7.1-8.5	The chief star of <i>h</i> 3376, C being 10.5 mag. and 6'.5 distant.
46	Lac. 165	8.1	35 13 39	29.7	310 2.0	8.2-10.7	
47	Lac. 236	6.9	47 12 44	15.1	355 1.8	7.3-8.1	
48	Lac. 272	7.2	54 0 67	6.0	342 0.75	7.5-8.8	The P.M. is insensible
49	Lac. 278	7.0	56 17 53	7.3	40 0.8	7.5-8.5	
50	C.Z. I. 293	9.0	1 12 42	37 48.4	140 1.0	9.4-10.4	Lac. 352, mag. 7.5, is 6 sec. f. 1½ N.
51	Lac. 460	7.0	30 6 46	12.4	15 1.4	7.2-9.9	
52	C.Z. I. 1092	8.0	43 31 44	28.2	180 1.0	8.5-9.5	The prec. of three stars in a curve.
53	Th-40°, 686	9.6	2 35 40	40 23.6	320 2.0	10.1-10.6	Closely N.p. C.Z. II. 953, mag. 8.3. Confirmed on Cape Cat. Plates.
54	C.Z. III. 123	8.7	3 5 0	41 44.7	320 0.7	9.4-9.6	Closely S.f. Bris. 484, mag. 8.3.
55	P. III. 19	6.2	8 55 44	47.7	185 0.8	6.8-7.3	This is the chief star of the old pair <i>h</i> 3556, the old companion being about 3" distant and of mag. 10.4. When measuring this star in 1856 Jacob remarked "A suspicion that A is a close double in a direction nearly south." Likely to be an interesting system.
56	C.Z. III. 426	8.4	15 6 43	0.4	260 2.5	8.6-10.5	Bris. 553, mag. 7.6, is N.f.
57	C.Z. III. 686	9.0	24 0 59	38.2	210 1.5	9.2-10.4	C.G.A. 3804, mag. 8.7, is 12 sec. f.
58	χ ₃ Fornacis	6.6	24 20 36	12.0	250 6.0	6.7-10.5	The central star of a group.

No.	Star.	Mag.	R.A. h m s	Dec. °	Estimated. p. Δ.	Mags.	Notes.
59	P. IV. 92	6.7	4 21 14	34 58.9	210 60	...	A and B + C.
60	Cape 1880, No. 2025	8.7	38 6	45 53.8	265	9.5-10.5	B and C = C.P.D. - 35°, 482.
61	Lac. 1805	7.8	5 15 14	41 8.8	270 2.0	9.4-9.5	
62	C.Z. V. 972	8.0	27 48 47	16.5	100 0.9	8.2-9.2	
63	Lac. 2024	7.1	45 39 48	57.0	175 1.0	8.4-9.4	In a small group with Lac. 1888, mag. 5.7.
64	P. V. 274	6.2	49 8 37	39.1	358 1.3	7.3-9.3	A 10 mag. star S.f. 90'' ±.
65	Lac. 2546	6.5	6 53 43	35 22.5	250 10.0	6.2-11.5	Another comes n.f. = 11 mag.
66	C.Z. VI. 2756	7.9	54 42 35	17.0	150 0.6	6.7-8.2	In a group of four stars.
67	B Velorum	5.4	8 19 27	48 10.2	255 2	8.1-9.6	In a group of four stars. C.Z. VI. 2754, mag. 9.5, is 15'' p.
68	C.Z. VIII. 2571	8.6	32 52 30	28.9	145 1	5.6-7.6	
69	P. VIII. 148	6.2	36 39 39	54.5	f. 4	8.8-10.3	
70	Lac. 3539	7.0	43 57 38	34.4	n.f. 2	6.3-9.0	
71	Bris. 2285	7.5	53 44 49	17.7	110° 1.5	7.2-9.2	
72	I Velorum	5.8	9 23 2	52 56.7	n.p. 5	7.7-9.2	The prec. of three stars.
					p. 50	-9.0	A and B + C.
73	Lac. 4315	7.2	10 24 52	48 28.6	...		B and C.
					s.p. 3	7.2-10.0	Another comes 10.5 mag. N.f. 20''. C.Z. X. 1741, mag. 7.8, is 8 sec. f. 3' N.
74	Bris. 3103-4	8.5	31 33 63	36.7	s.p. 2	8.7-10.3	Lac. 4376, mag. 8.0, is about 30' S. prec.

No.	Star.	Mag.	R.A. h m s	1900. S.Dec. °	Estimated. p. Δ. " s.f.	Mags.	Notes.
75	Anon.	8.5	34 12 64	30 30	3	9.0-9.5	Lac. 4405, mag. 7.5, is 40 sec. p. 1' S., and 20' further S. will be found a fainter pair observed at Cordoba = C.Z. X. 2403.
76	Th-30°, 9211	9.5	11 22 23	30 11.3	n.f.	3 10 -10.5	
77	o, Centauri	5.2	27 8 58	53.4	s.f.	11 5.2-9.0	
78	P. XI. 105	5.7	28 45 40	2.1	91°	1 6.5-6.5	P. XI. 101, mag. 6.2, orange coloured, is 49 sec. p. 9' N.
79	C.Z. XI. 3331	7.8	49 46 41	50.2	...	0.75 8.6-8.6	C.Z. XI. 3342, mag. 8.3, is 12 sec. f. 3' N.
80	C.Z. XI. 3367	7.5	50 20 41	20.8	N.p.	2 8.3-8.3	
81	C.Z. XII. 548	9.0	12 9 46	29 12.7	N.	1 9.4-10.4	
82	Bris. 4084	7.9	25 57 40	57.1	N.p.	1 8.3-9.3	Lac. 5173, mag. 6.6, is N.p.
83	Bris. 4251	7.0	50 59 47	8.7	p.	0.8 7.5-8.0	
84	Lac. 6138	7.5	14 48 41	36 1.3	S.p.	4 7.7-9.7	An 8.5 mag. star is 5½' S.
85	C.Z. XIV. 3624	8.5	58 34 35	32.1	181°	1.5 8.9-10.0	C.Z. XIV. 3631, mag. 9.1, is 4 sec. f. and N.
86	Th-37°, 10168	9.5	15 14 58	37 54.3	p.	1 9.9-10.9	Closely S.p. a neat easy pair Lac. 6329, noted at this observatory 20 years ago.
87	C.Z. XV. 1167	9.2	18 48 38	23.2	p.	1 9.9-10.0	ℓ Lupi mag. 5.1 is 90' N.f.; and has a faint comes at 60" ± N
88	Lac. 6437	5.8	31 23 52	2.6	...	... 9.5-10.1	A and B + C = Dunlop. 189. B and C.
89	Lac. 6471	6.8	34 29 39	39.4	s.f.	1 7.0-9.0	The P.M. is insensible.
90	Lac. 6530	7.3	41 55 25	40.6	10°	1 7.4-10.4	O.A. 14870, mag. 8.5, is a little way N.p.

No.	Star.	Mag.	R.A. h m s	1900. S. Dec. ° ' "	Estimated. p. Δ.	Mags.	Notes.
91	P. XVI. 37	6.3	16 13 47	39 11.2	290 6	6.4-10.6	
92	Lac. 6796	7.3	15 0 33	3.0	N.p. 6	7.4-10.0	Another comes at 45" S.f. and Lac. 6797, mag. 7.3, is about 6' N.f.
93	Lac. 6822	7.7	19 28 47	49.0	300° 0.8	7.8-10.0	Very difficult.
94	Lac. 6837	7.7	19 31 29	41.5	195 1	7.9- 9.9	h 4850, mag. 5.7, a wide pair, is 69 sec. N.p.
95	Lac. 6871	7.3	26 32 33	19.1	350 1.5	7.5- 9.5	
96	Lac. 6912	5.6	33 51 48	34.0	180 9	5.7-12.0	A and C. A and B, 12°, 2" mag. 9.5, was found at Melbourne in 1878. A and D, mag. 7.1, 10", was observed by h.
97	C.Z. XVI. 2233	8.5	33 56 48	33.5	N.f. 2	8.6-11.3	A very beautiful quadruple star followed by a group of stars, one of which is double.
98	Lac. 6933	6.9	16 35 48	53.0	85 1	7.3- 8.3	In a group of stars.
99	C.Z. XVI. 2834	7.5	42 22 43	46.0	N.f. 1	7.9- 8.9	Both yellow.
100	Lac. 6969	6.8	47 39 73	15.8	S.f. 0.8	7.0- 8.5	
101	C.Z. XVI. 3270	9.0	47 55 40	53.5	355 1	9.4-10.4	Lac. 7029, mag. 6.4, is S.f. and C.Z. XVI. 3280, mag. 8.9, is N.f.
102	Lac. 7120	7.3	17 0 7	44 18.4	130 4	7.4- 9.9	
103	C.Z. XVII. 480	8.0	9 3 33	43.2	320 0.7	8.4- 9.4	One night only.
104	Lac. 7146	7.0	9 7 69	55.8	S.f. 2	7.1-10.0	Apodis, mag. 5.8, is S.f.
105	C.Z. XVII. 1604	8.4	25 11 30	12.9	173 2	9.1- 9.3	C.Z. XVII. 1603, mag. 8.5, is 2' 8 N.p.

No.	Star.	Mag.	R.A. h m s	1900. S.Dec.	Estimated. p. Δ.	Mags.	Notes.
106	Lac. 7344	7.7	29 35 49	10.8	150 1"	8.1-9.1	λ Arae, mag. 5.6, is 10' S.f.
107	C.G.A. 10 (Mess. 6)	8.9	33 0 32	17.5	130 1.5	9.3-10.3	Closely S.p. P. XVII. 159.
108	Th. - 40°, 11849	9.3	40 59 40	5.8	...	1.5	1 Scorpii, mag. 3.3, is 24 sec. p. 1' N.
109	C.Z. XVII. 3241	9.3	49 24 28	3.6	S.p.	2.7	9.7-10.5
110	Lac. 7503	7.5	51 52 47	45.8	125 1.5	7.7-9.7	Followed by two stars, mags. 7.2 and 8.3.
111	Lac. 7593	7.2	18 7 37	56 40.7	310 1	7.3-9.8	Lac. 7891, mag. 7.1, is closely N.f.
112	Lac. 7889	6.7	46 33 47	23.7	S.	2	6.8-10.0
113	Bris. 6535	6.9	51 18 48	38.4	225 3	6.9-11.0	
114	C.G.A. 26377	7.8	19 10 32	63 4.5	280 0.7	8.2-9.0	An 8.5 mag. star 27 sec. p.
115	I. Melb. 983	7.9	16 37 62	22.5	315 3	8.0-11.0	
116	C.Z. XIX. 647	8.4	16 43 46	0.8	170 1.7	8.7-10.0	C.Z. XIX. 648, mag. 8.6, is 17" S.
117	Lac. 8102	6.9	23 26 60	28.6	180 1	7.3-8.3	
118	Lac. 8124	7.0	25 32 46	59.0	137 1	7.1-9.6	
119	Lac. 8163	7.4	34 0 59	14.2	175 1.2	7.7-9.0	
120	Lac. 8194	7.1	40 14 62	3.5	185 0.8	7.6-8.1	A and B. A + B and C = h 5141 seems unchanged.
121	Lac. 8207	5.5	42 16 59	26.6	80 0.7	5.7-7.7	A very fine pair.
122	P. XIX. 266	7.6	43 45 42	6.6	330 4	7.7-10.5	
123	Lac. 8352	7.1	20 3 30	47 1.6	177 6	7.2-11.0	
124	Bris. 6817	7.7	9 30 63	28.0	45 2	7.8-10.5	Lac. 8368, mag. 6.7, is closely S.f.

No.	Star.	Mag.	R.A. h m s	1900. S.Dec. ° ' "	Estimated. p. Δ.	Mags.	Notes.
125	C.Z. XX. 252	8.2	9 32 46	12.8 40 1'		8.6-9.4	An 8.5 mag. star follows s.
126	C.Z. XX. 438	9.0	15 19 57	25.6 p. 1		9.5-10.0	The most N. of a small triangle of 9 mag. stars, about 40 S.p. α Pavonis, mag. 2.1. First seen by Mr. Innes at Sydney 1894, but not then clearly identified.
127	ν Microscopii	5.6	27 3 44	51.3 N.f. 65		5.7-9.0	A and B + C.
128	Bris. 6902	7.8	36 18 52	9.4 325	0.6	9.5-10.0	B and C. Guesses; too close for the telescope.
129	Rumk. 529	7.9	48 34 59	39.2 30 1	2.3	7.9-10.4	η Indi, mag. 4.7, is 25 sec. f. 7' S.
130	Lac. 8650	7.0	57 15 48	21.3 313	3.2	8.1-10.1	C.Z. XX. 1552, mag. 8.4, a neat pair first noted at Cordoba, is 15' N.f.; and C.Z. XX. 1547, mag. 8.5, is also in the field.
131	Anon.	9.0	21 14 47	52 12.3 N. 1		7.1-11.0	Discovered by Mr. Innes on 1894 Dec. 4 at Sydney, but not sufficiently identified at the time.
132	Lac. 8779	7.5	16 5 52	22.0 300	1.3	9.5-10.0	Lac. 8767, mag. 6.6, is 20 sec. p. 1' 8 N.
133	C.Z. XXI. 664	8.5	23 4 39	15.9 ... 4			The pair is the last of a group of four stars
134	Lac. 9104	7.7	22 16 3	56 39.4 300	0.6	7.6-10.0	The S.f. of 3 stars in the finder.
135	π ₁ Gruis	6.7	16 37 46	27.1 190	2.5	8.6-11.0	Very neat; the chief star is red.
136	C.X. XXII. 554	7.5	19 53 45	37.2 265	1.8	8.1-8.5	C.Z. XXII. 559, mag. 8.0, is 11.5 sec. f. 7' N.
137	Lac. 9125	6.9	20 46 58	30.6 315	1.5	7.7-9.2	Difficult. C.G.A. 30613, mag. 7.6, is 20 sec. f.
						7.0-10.5	

No.	Star.	Mag.	R.A. h m s	1900. S. Dec.	Estimated. p. Δ.	Mags.	Notes.
138	Lac. 9188	6.6	32 0 40	22° 6'	290 2.5	6.7-11.0	Similar to β 771, which is 44' S., but the new pair is closer and the <i>comae</i> fainter.
139	η Gruis	5.1	39 30 54	1° 6'	180 1.5	5.1-12.5	Seen whilst trying to verify a suspected duplicity in the chief star towards 320°.
140	Lac. 9241	8.2	41 36 55	1° 5'	270 3	8.4-10.4	The last of a group of stars.
141	O.A. 22432	9.1	43 51 20	47° 3'	N.p. 2	9.6-10.1	
142	C.Z. XXIII. 160	7.5	23 7 33	32° 51' 6"	270 4	7.6-11.0	
143	Lac. 9405	7.2	9 36 60	14° 3'	5 2.5	7.3-10.5	
144	Lac. 9467	8.1	20 13 43	26° 9'	5 0.9	8.5-9.5	
145	C.Z. XXIII. 644	8.7	25 20 58	39° 8'	80 1.3	9.0-10.3	C.Z. XXIII. 655, mag. 8.5, is 21 sec. f. 6' S.
146	Lac. 9641	7.3	49 54 37	55° 2'	215 0.75	7.8-8.3	A star 7.7 mag. is 71 sec. p. $2\frac{1}{2}$ ' S.

New Double Stars noted at the Transit Circle.

1	Th. -41°, 178	8.7	0 36 2	41° 45' 3"	260 4	9.2-9.7	Discovered by Mr. Power.
2	C.Z. I. 98	8.3	1 5 0	40° 40' 5"	80 2.5	8.8-9.3	" Cox.
3	C.Z. III. 108	9.2	3 4 30	42° 53' 8"	250 2	9.8-10.1	" "

Angles, &c., estimated at the 7-inch equatorial.

*Corrections to lists of Double Stars.**Monthly Notices*, vol. lv. p. 312.

No. 1. λ *Toucanæ*. Identification erroneous. This pair is U.A. 64 *Toucanæ*, which was noted as a double star at Cordoba in 1873.

No. 18. Identification erroneous. The star is Lac. 8602. Position for 1900 R.A. $20^h47^m53^s$. Decl. $-52^\circ29'7$.

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No. 42. This star is single in the 7-in. equatorial of this Observatory. Star probably wrongly identified at time of first observation.

Royal Observatory:
Cape of Good Hope.

Micrometrical Measures of the Double Stars in the Great Nebula and Cluster Surrounding η Carinæ, made with the 24-inch Refractor of the Lowell Observatory. By T. J. J. See, A.M., Ph.D. (Berlin).

Micrometrical measures of the double stars in the great nebula and cluster surrounding η *Carinæ* would seem to be a desirable supplement to the determination of the positions of the 217 single stars of that interesting region made by Gould, and embodied in the *Argentine General Catalogue*, pp. 625-630. The earlier work of Sir John Herschel in the same region led him to detect and to measure the approximate angles and distances of some of the double stars given below; we have compared his results with those here obtained, and there are thus disclosed in several cases measurable differences, which are most probably due to changes in the past sixty years. Our observations have been made when the cluster was within an hour of the meridian, and, therefore, at an altitude of about 11° .

It will readily be understood that the atmospheric spectra of stars seen at our station, 7,600 feet above sea level, are much less troublesome than at places where the atmosphere is denser, yet it is apparent that exact micrometrical measurement is a matter of some difficulty, and hence in this work we have been careful to select nights when the seeing was good. Accordingly, although the objects were measured within 11° of the horizon, and more or less involved in the nebulosity which extends throughout the

cluster, the definition on the whole was very satisfactory, and the resulting measures will not, I think, be affected by any considerable errors.

The whole region has been very carefully examined, and all objects measured which seemed to possess any real interest. The objects are arranged and numbered in order of right ascension, and wherever possible, I have given the corresponding numbers in Gould's very accurate catalogue of this cluster (G). The positions of the stars are referred to the equator and mean equinox of 1900.0.

No. 1 = G 10.

$$\alpha = 10^{\text{h}} 36^{\text{m}} 46^{\text{s}}.0; \delta = -59^{\circ} 1' 19''.0.$$

8.2, yellow; 11.6, bluish yellow.

t	θ_0	ρ_0	
1897.181	274 [°] .1	17 ^{''} .42	seeing 5

No. 2 = H₂ 4347.

$$\alpha = 10^{\text{h}} 38^{\text{m}} 19^{\text{s}}.0; \delta = -59^{\circ} 22' 59''.0.$$

10, yellow; 11.7, bluish yellow.

1897.178	303 [°] .2	3 ^{''} .35	seeing 5	close system.
1897.179	304.6	3.54	5	
1897.181	307.1	2.42	5	
1897.184	...	3.25	5	
1897.180	305.0	3.14		

No. 3. Triple.

$$\alpha = 10^{\text{h}} 38^{\text{m}} 21^{\text{s}}.5; \delta = -59^{\circ} 26' 35''.7.$$

10.4, yellow; 11.7, yellow; 12.9, bluish yellow.

AB. New.

1897.181	349 [°] .2	2 ^{''} .88	seeing 5
1897.182	348.3	3.12	5
1897.184	347.1	2.74	5
1897.185	345.2	3.44	5
1897.183	347.5	3.05	

AC = H₂ 4348.

1897.181	259 [°] .3	13 ^{''} .84	seeing 5
1897.182	259.9	13.89	5
1897.184	259.6	14.24	5
1897.185	259.5	14.03	5
1897.183	259.6	14.00	

No. 4 = H₂ 4354. $\alpha = 10^h 39^m 57^s.2$; $\delta = -59^\circ 34' 20''.9$.

10.6, yellow; 12.6, bluish.

1897.175	218.4	10.25	seeing 5	
1897.176	216.9	10.42	5	
1897.178	216.9	10.49	5	
1897.176	217.4	10.39		
Herschel 1836.471	228.4	12		12

No. 5 = G 78.

 $\alpha = 10^h 40^m 3^s.0$; $\delta = -59^\circ 1' 32''.1$.

8.5, yellow; 12.4, bluish yellow.

1897.181	236.7	7.27	seeing 5	
1897.182	237.0	6.76	5	
1897.184	240.7	7.85	5	
1897.185	241.7	7.40	5	
1897.183	239.0	7.32		

No. 6 = G 80 = H₂ 4356. $\alpha = 10^h 40^m 5^s.8$; $\delta = -59^\circ 1' 21''.2$.

7.5, orange yellow; 11.9, bluish purple.

1897.175	151.6	2.75	seeing 6	Physical system
1897.176	149.6	2.74	6	
1897.178	147.4	3.07	5	
1897.181	147.9	2.76	5	
1897.178	149.1	2.83		
Herschel 1836.463	150.5	2	Mags. 7.5; 9	
1837.312	147.3	2	8; 11	

No. 7 = G 82 = H₂ 4359. $\alpha = 10^h 40^m 7^s.6$; $\delta = -59^\circ 34' 0''.8$.

10.4, yellow; 12.6, bluish.

1897.175	234.6	6.74	seeing 5	
1897.176	234.8	6.66	5	
1897.178	232.8	6.52	5	
1897.176	234.1	6.64		
Herschel 1837.309	238.6	6		12

No. 8 = G 83. New.

$$\alpha = 10^h 40^m 8^s.3; \delta = -59^\circ 0' 57''.4.$$

9.4, yellow; 13, bluish yellow.

1897.175	306.8	4.17	seeing 5
1897.176	307.2	4.11	5
1897.178	305.4	3.55	5
1897.181	303.1	3.37	5
1897.177	305.6	3.80	

No. 9 = H₂ 4358.

$$\alpha = 10^h 40^m 10^s.6; \delta = -59^\circ 34' 31''.6.$$

10.4, yellow; 12.7, bluish.

1897.175	192.3	8.36	seeing 5
1897.176	192.7	7.95	5
1897.178	194.2	8.04	4
1897.176	193.1	8.12	

Herschel 1837.309 199.4 8 12

No. 10 = ZC 2864 = H₂ 4360. Triple.

$$\alpha = 10^h 40^m 15^s.5; \delta = -59^\circ 3' 1''.8.$$

A = 8.3, yellow; 9.0, yellow; 9.3, yellow.

BC.

1897.175	118.2	1.67	seeing 5
1897.176	120.8	1.84	6
1897.178	118.0	1.84	4
1897.176	119.0	1.78	

Herschel 1837.309 111.3 1 12

$$\frac{BC}{2} \text{ and } A = B \ 3190.$$

1897.175	108.6	14.27	seeing 5
1897.176	108.2	14.29	6
1897.178	108.3	13.91	4
1897.176	108.4	14.16	

Herschel 1834.197 102.7 15
1837.309 106.8 12

No. 11 = G 107 = B 3194.

 $\alpha = 10^h 40^m 42^s.1$; $\delta = -59^\circ 12' 45''.8$.

9, yellow; 9.2, yellow.

1897.181	213 ⁰ .7	18 ^{''} .81	seeing 5
1897.182	214.0	18.64	5
1897.182	213.8	18.72	

There is a small double n.p. this system, $90^\circ \pm$, $3''.8 \pm$ mags. 12.5; 13, both yellow.

Herschel 1834.197 206⁰.1 12^{''} 1ⁿ

No. 12 = A.G.C. 14715 = H₂ 4364. Triple. $\alpha = 10^h 40^m 51^s.4$; $\delta = -58^\circ 50' 3''.0$.

8.9, yellow; 10.1, yellow; 11.1, yellow.

AB.

1897.175	354 ⁰ .6	8 ^{''} .27	seeing 5
1897.178	355.5	7.92	5
1897.176	355.1	8.09	

AC.

1897.175	147 ⁰ .4	[8 ^{''} .27 $\pm$]	seeing 5
1897.178	148.1	9.46	5
1897.181	146.8	9.47	5
1897.178	147.4	9.46	

No. 13, system n.f. η Carinæ = H₂ 4366. $\alpha = 10^h 41^m 11^s.4$; $\delta = -59^\circ 9' 32''.7$.

11.4, bluish yellow; 12.8, bluish yellow.

1897.175	141 ⁰ .0	5 ^{''} .28	seeing 5
1897.176	141.2	5.40	5
1897.178	144.5	[4.47]	5
1897.181	143.9	5.19	5
1897.182	143.2	5.51	5
1897.178	142.8	5.35	

A and η Carinæ (H₂ 4366, No. 2).

	1897·175	37 [°] 7	13 ^{''} 82	seeing 5
	1897·178	41·6	14·33	5
	1897·181	38·9	14·30	5
	1897·178	39·4	14·15	
Herschel	1834·197	30·3	15	A and η Carinæ.
	1834·197	46·8	12	B and η Carinæ.

No. 14 = ZC 2946.

 $\alpha = 10^h 41^m 20^s \cdot 1$; $\delta = -59^\circ 13' 30'' \cdot 0$.

9, yellow; 9·5, yellow.

	1897·192	190 [°] 3	16 ['] 12	seeing 3	Hazy.
	1897·193	190·9	15·75	3	
	1897·192	190·6	15·94		

No. 15 = A.G.C. 14744 = H₂ 4369. $\alpha = 10^h 41^m 57^s \cdot 1$; $\delta = -58^\circ 57' 45'' \cdot 2$.

7·3, reddish; 12·1, bluish purple.

	1897·175	40 [°] 7	14 ^{''} 60	seeing 5
	1897·178	41·4	14·96	4
	1897·179	41·3	14·92	4
	1897·177	41·1	14·83	

No. 16 = G 166.

 $\alpha = 10^h 43^m 23^s \cdot 2$; $\delta = -59^\circ 34' 1'' \cdot 4$.

8·5, yellow; 11·5, bluish.

	1897·181	115 [°] 5	16 ^{''} 78	seeing 5
	Faint system n.f. at dist. of 25'' $\pm$.			

	1897·181	274 [°] 6	8·28	seeing 5
	Magnitudes 10·5, 11·5, both yellow.			

No. 17 = G 190 = H₂ 4374. $\alpha = 10^h 44^m 58^s \cdot 8$; $\delta = -58^\circ 55' 6'' \cdot 4$.

9·4, yellow; 12·8, bluish yellow.

	1897 192	117 [°] 5	14 ^{''} 89	seeing 4	Hazy.
	1897·193	117·3	14·52	3	
	1897·192	117·4	14·71		

No. 18 = ZC 3447 = A.G.C. 14880.

 $\alpha = 10^h 48^m 21^s.8$; $\delta = -58^\circ 12' 56''.9$.

9, yellow; 12.5, bluish.

1897.192	217.9	3.89	blurred, hazy.
1897.193	218.3	3.29	seeing 3
1897.192	218.1	3.59	

Although the above comparison does not indicate any very large or certain motion in the double stars of this group, I think it probable that some of the apparent changes are real. If some of the systems should be found to be in motion the result would ultimately possess a high value, as throwing light upon the connection of the stars of this cluster with the nebula in which they are projected. The region is remarkably rich in fairly close double stars, and one would naturally think that some of them at least are physical systems; but it may require ages for their motions to develope.

It had been my intention to make a very careful drawing of this great nebula, but it now seems best to defer the execution of the plan till a more convenient location of the observatory further south shall furnish more favourable conditions for a faithful delineation of its many delicate and wonderful details. It seems proper to add that when viewed with the 24-inch refractor the striking phenomena disclosed have no close resemblance to the drawings executed by Sir John Herschel, nor to the photographs recently secured by Dr. Gill. The greatly increased detail shown renders the appearance one of great complexity, and hence a really authoritative sketch will require the most favourable conditions, besides the exercise of much skill and care.

Lowell Observatory, City of Mexico :
1897 March 15.

The Orbit of μ Draconis. By S. W. Burnham.

As a double star this is known as Σ 2130 (= H II. 13 = Sh 242). It was discovered by Herschel I. 1779 October 17, and, as the distance was between 4" and 8", it was placed in his Class II. Both angle and distance were measured, and the latter recorded as 4".354 "mean measure" (*Phil. Trans.* 1782). In his "Synopsis" of his father's double-star observations (*Mem. R.A.S.* vol. xxxv.) Herschel II. gives this distance as 4".69, and the date a few days later than that in the original publication, and the date of the measure of the position angle as 1781.73. The latter

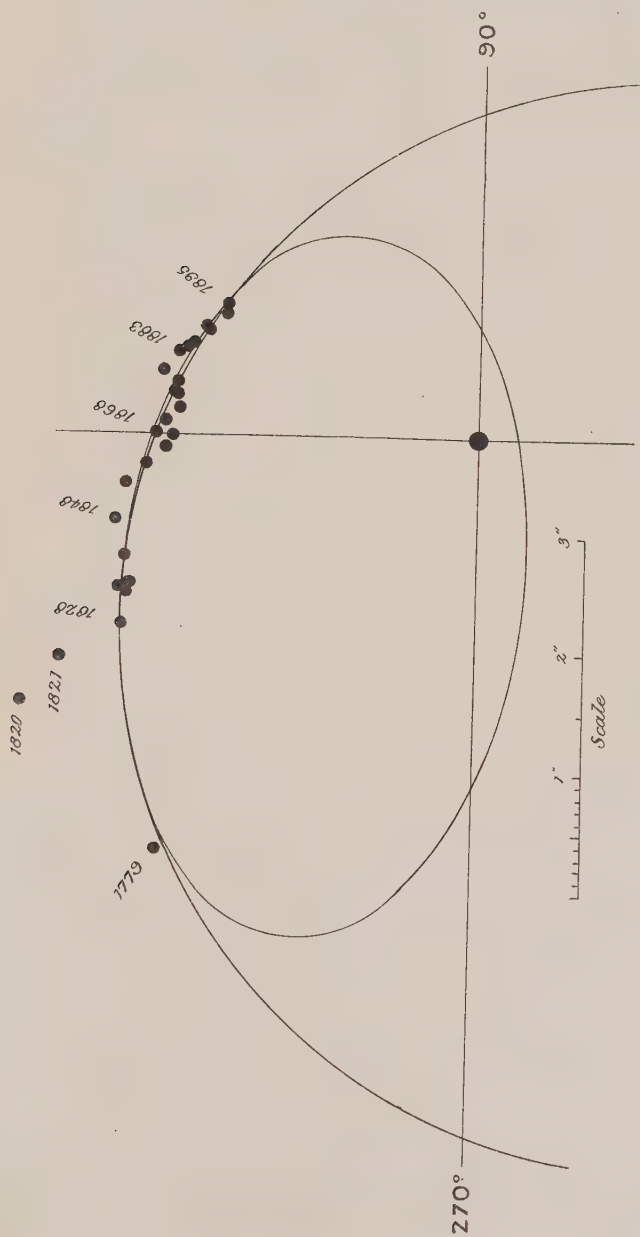
would seem to be a mistake, since Herschel I. has only the single observation of 1779 October 19 in his first catalogue above referred to. There may be some warrant for this in the original MS., and for increasing the distance to $4''\cdot69$; but the smaller distance value is used in Herschel and South's Catalogue of 1824, and in the early measures of Dawes and other observers. I have used here the original values of both distance and epoch.

In 1804 Herschel recognised the angular motion, and said, "The stars being of nearly equal magnitude, we can have no inducement to suppose them to be at very different distances from us." Struve made measures of it in 1819 and 1821 before the commencement of the work recorded in *Mensuræ Micro-metricæ*, and South and Herschel have a single observation in 1821. After citing the previous measures, the latter observers say: "No doubt, therefore, can remain of the reality of an angular motion in this star, as announced by Sir William Herschel in 1804; and the observations here brought together prove it to have been hitherto nearly uniform, and averaging $0^{\circ}\cdot579$ per annum in the direction *npsf*, or retrograde. There can be little doubt of its being a binary system—a miniature of a *Geminorum*."

Systematic work on this star was commenced by Struve in 1828, and since that time there is no lack of carefully made reliable mean results from measures on different nights down to the present time. The retrograde motion recognised by the early observers has steadily continued, accompanied with a slow diminution in the distance. According to Struve, the magnitudes of the components are 5 $\cdot$ 0 and 5 $\cdot$ 1.

On the accompanying diagram (Plate 18), I have given a careful selection of the best measures by the principal observers for the last hundred years. The following dates and observers are represented by complete measures of angle and distance:—

1781	1 n Hl	1872	7 n De
1820	2 n Σ	1875	7 n Du
1821	1 n Sh	1876	3 n Jed
1828-36 (4)	13 n Σ	1877	8 n Hall
1840	6 n Da	1879	3 n Jed
1848	1 n Da	1883	10 n Per, En, Jed
1855	15 n De	1885	7 n Hall, Per, Jed
1858	3 n De	1886	3 n Jed
1863	7 n De	1888	3 n Maw
1866	6 n De	1889	10 n β , Hall, Maw
1868	3 n Du	1893	7 n Leavenworth, Comstock
1871	11 n O Σ , Du	1895	10 n See, Collins, Comstock



Orbit of μ Draconis.

It is evident that the distances in the early measures of Struve, and Herschel and South, 1819 to 1821, are too large, or that the distance in 1781 is too small. The later measures of Struve appear to show that his previous measures of distance were much too large, and he seems to have considered them as not very reliable, since they are not mentioned in *Mensuræ Micrometricæ*.

One orbit has been computed for this system. Berberich (*Astr. Nach.* 2582), from an examination of the measures down to 1883, found a period of 6480 years. As in all double stars as wide as this, and as easy of measurement, where the observed arc is short, the various measured positions are well represented by the apparent orbit; and, so far as the agreement between the observed and computed places is concerned, there is nothing for unfavourable criticism; but it is obvious enough from even a casual inspection of the diagram that the data are altogether insufficient for even the roughest approximation to the apparent ellipse and the elements of the real orbit. Indeed, as might be expected, the measures since 1883 are steadily leaving the computed positions. The chances are that the relative change will finally resolve itself into orbital motion; but, judging from the motion in the last hundred years, it will be a very long time before anything more than the bare fact of physical connection can be established, to say nothing about the details of that relation.

Doberck gives formulæ for the angles and distances (*Trans. R.I. Acad.* vol. xxvi.), and a comparison of the positions thus found with some of the measures from 1781 to 1875. For this interval the theory holds fairly well, but the measures since that time are not so well represented.

By way of showing how easily these positions are represented by orbits wholly unlike in all respects, I have given on the diagram two of the many which could be found. So far as the observed arc is concerned, these figures are practically identical, and represent all the measures down to 1883 as well as, if not better than, the computed orbit, and the six later positions are much better represented. Herschel's distance is practically perfect, and the angle requires a correction of only $2^{\circ}.8$, which is much less than the probable error of measures made in the last century. The ellipse with a major axis of $5''.88$ gives a period of about 280 years, and the circle with a diameter of $9''.16$ a period of 1,190 years, the eccentricity in the one case being 0.84, and zero in the other. Of course an almost infinite variety of conic sections could be shown which would be equally satisfactory, so far as the measures are concerned.

In 1889, with the 36-inch refractor of the Lick Observatory, I detected a third star (β 1088), exceedingly faint, at a distance of about $12''$ from B. Four sets of measures have been made of this star since that time—the last in 1895—and they appear to indicate that this minute companion has the same proper motion

as the bright stars. These measures have the following differences from the mean :—

1889.27	—0 ^o .2	—0 ^{''} .02	3 ⁿ β
1891.30	+1 ^o .0	+0 ^{''} .03	3 ⁿ β
1892.36	—0 ^o .6	+0 ^{''} .12	3 ⁿ β
1895.28	—0 ^o .1	—0 ^{''} .13	3 ⁿ B

These measures were all made with the 36-inch refractor, the last by Barnard in 1895. If the small star is stationary, the proper motion of the large star during the interval covered by the measures would increase the distance of C about 0^{''}.4, and make the angle 3^o less, and such a change one would expect to appear in the measures. The close agreement of the measures renders it improbable that any such change has taken place. However, the new star is a faint object even with the large aperture, and a longer interval may be necessary to establish with certainty the fact of common proper motion.

Cometary Observations at the Liverpool Observatory, 1896. By W. E. Plummer, M.A.

This paper is practically a continuation of that given in the June number of the *Monthly Notices* of last year, and the remarks there made apply equally to the observations here given. The instrument and the micrometers employed, as well as the method of reduction pursued, are precisely the same as those mentioned in the earlier paper. The abbreviations given in the column headed 'No. of Comparisons' are also explained in that place. The comets have mostly been faint objects, and the use of the filar micrometer has generally been impossible. In the case of Swift's Comet of last April the approximate sub-polo position did not permit the instrument to be reversed, so that any error in the orientation of the micrometer has a very injurious effect. On some occasions portions of the object-glass were cut off by the mounting of the instrument.

Comet 1896 I. (Perrine-Lamp).

Comet 1890 I. (Ferris-Lamp).												
Greenwich Mean Time of Observation.	No. of Comparisons (a)		No. of Comparisons (b)		Apparent Declination of Comet.		Log. Factor of Parallax in (a)		Letter of Refer- ence.			
	h	m	s	h	m	s						
1896 Feb. 22	16	22	57.2	25	21	0	57.78	+ 3 18.7	5	+ 27 56 42.6	0.8245	a
22	16	22	57.2	25	21	0	57.65	+ 2 11.3	5	+ 27 56 43.2	0.8245	b
23	16	30	16.0	25	21	22	10.50	+ 4 23.9	5	+ 32 34 48.7	0.8179	c
Mar. 1	7	26	45.4	Ret.	0	18	6.84	+ 8 10.7	Ret.	+ 50 50 35.2	0.6072	d
1	7	26	45.4	"	0	18	5.31	~ 9 12.1	"	+ 50 50 37.0	0.6072	e
3	9	0	34.6	20	1	5	44.60	+ 10 9.7	5	+ 51 44 54.4	0.6934	f
4	10	40	10.0	15	1	26	41.36	+ 7 13.8	4	+ 51 44 43.0	0.8034	g
4	10	40	10.0	15	1	26	41.85	+ 6 29.1	4	+ 51 44 37.7	0.8034	h
9	9	16	3.7	Ret.	2	35	13.59	+ 4 0.3	Ret.	+ 50 0 48.7	0.6192	i
9	9	16	3.7	"	2	35	13.67	- 38.0	"	+ 50 0 48.3	0.6192	j

Greenwich Mean Time of Observation.	$\phi - \star$ R.A. h m s	$\phi - \star$ R.A. s	No of Comparisons (a)	Apparent R.A. of Comet. h m s	$\phi - \star$ Declina- tion.	No. of Comparisons (b)	Apparent Declination of Comet. ° ' "	Log. Factor of Parallax in (a)	Letter of Refer- ence.
1896 Mar. 11	9 10 50.2	+2 8.19	Ret.	2 53 24.72	- 4 49.6	Ret.	+49 4 42.6	+9.7259	k
11	9 10 50.2	+1 39.94	"	2 53 24.80	- 1 0.1	"	+49 4 40.9	+9.7259	l
16	9 28 42.5	-1 22.62	"	3 25 34.97	- 1 54.0	"	+46 53 52.4	+9.7091	m
19	10 2 11.3	+1 44.57	"	3 39 8.15	+ 25.0	"	+45 46 55.9	+9.7038	n
21	8 53 11.4	- 18.06	"	3 46 24.60	- 3 54.2	"	+45 8 30.7	+9.6801	o
<i>Comet 1896 III. (Swift).</i>									
Apr. 21	9 1 13.7	+1 51.18	Ret.	3 32 53.80	+ 9 24.9	Ret.	+30 56 7.2	+9.5886	a
22	8 53 30.0	-1 31.92	25	3 30 48.03	+ 3 50.5	5	+33 34 59.8	+9.6023	b
23	9 10 5.2	+3 12.32	20	3 28 19.37	+ 5 12.8	5	+36 13 4.9	+9.5986	c
24	9 14 16.1	+1 10.11	25	3 25 30.73	- 2 1.9	6	+38 45 39.0	+9.6033	d
24	9 14 16.1	-1 41.94	25	3 25 30.69	-11 52.1	6	+38 45 37.6	+9.6033	e
28	9 26 35.3	+1 21.05	25	3 10 42.01	+ 3 4.1	5	+47 56 58.5	+9.6166	f
28	9 26 35.3	+1 4.95	25	3 10 41.99	+12 8.7	5	+47 56 59.3	+9.6166	g
29	10 3 52.9	+ 16.44	Ret.	3 6 1.95	- 3 32.0	Ret.	+50 0 34.4	+9.5497	h
29	10 3 52.9	- 38.57	"	3 6 2.17	+ 0 58.8	"	+50 0 32.5	+9.5497	i
May 1	10 16 40.0	-3 47.83	19	2 55 57.82	- 2 33.8	4	+53 40 14.3	+9.5066	j
1	10 16 40.0	-3 54.00	19	2 55 57.92	- 2 29.4	4	+53 40 11.2	+9.5066	k
3	11 9 37.1	-1 46.69	25	2 44 35.29	- 51.5	5	+56 53 42.5	+9.2079	l
3	11 9 37.1	- 11.91	25	2 44 35.26	+ 3 54.2	5	+56 53 40.9	+9.2079	m
4	10 13 30.4	+6 26.26	Ret.	2 38 50.70	+ 2 37.3	Ret.	+58 15 22.5	+9.5395	n

Greenwich Mean Time of Observation.		*—* R.A. s		No. of Comparisons (a)		Apparent R.A. of Comet.		Declination.		No. of Comparisons (b)		Apparent Declination of Comet.		Log. Factor of Parallax in (a)		Letter of Refer- ence.	
		h m s				h m s		° ' "				° ' "		in (a)			
1896 May	4	10	13	30.4		-1 42.83	Ret.	2 38	51.06	-	8	26.3	Ret.	+9.5395	0.8792	o	
	5	10	29	59.7		+2 58.80	20	2 32	35.70	-	3	28.4	5	+9.3652	0.8966	p	
	6	9	49	50.5		-1 15.42	"	2 26	24.38	+	6	10.7	"	+9.5149	0.8789	q	
	6	9	49	50.5		-1 31.87	"	2 26	25.02	-	13.2	"	"	+9.5149	0.8789	r	
	7	11	0	11.2		+2 33.90	25, Ret.	2 19	32.24	-	4	41.1	5, Ret.	+8.9375	0.9011	s	
	7	11	0	11.2		- 51.53	"	2 19	31.57	+	10	23.1	"	+8.9375	0.9011	t	
	8	10	36	40.3		+ 17.02	Ret.	2 12	56.64	+	3	32.1	Ret.	+9.1248	0.8955	u	
	8	10	36	40.3		+4 50.34	"	2 12	56.39	+	10	51.0	"	+9.1248	0.8955	v	
	9	10	20	32.2		-4 33.35	"	2	6.10.97	-	4	43.5	"	+9.1943	0.8904	w	
	9	10	20	32.2		-6 1.21	"	2	6 10.72	+	23.0	"	"	+9.1943	0.8904	x	
	10	10	44	0.1		-1 44.39	"	1 59	7.07	+	12	4.9	"	+8.6180	0.8916	y	
	10	10	44	0.1		+2 16.94	"	1 59	6.13	+	8	25.1	"	+8.6180	0.8916	z	
	11	11	3	50.0		+5 36.34	"	1 51	58.34	-	6	59.3	"	-8.8789	0.8877	aa	
	12	11	56	29.4		+3 15.69	"	1 44	36.87	+	2	0.5	"	-9.4995	0.8668	bb	
	12	11	56	29.4		- 8.83	"	1 44	37.15	+	4	44.6	"	-9.4995	0.8668	cc	
	13	11	45	16.3		-2 46.73	"	1 37	29.41	+	16	25.1	"	-9.5108	0.8637	dd	
	16	10	40	26.0		+3 18.19	"	1 16	6.95	+	3	43.1	"	-9.3419	0.8677	ee	
	19	11	2	3.1		-0 21.09	"	0 54	17.60	-	2	47.0	"	-9.6976	0.8360	ff	
	19	11	2	3.1		+2 57.48	"	0 54	16.92	-	1	11.0	"	-9.6976	0.8360	gg	
	2	11	35	50.4		+0 15.98	"	23	16 8.89	-	1	12.7	"	-0.0568	0.5591	hh	

Comet I. 1897 (Perrine, 1896 November 2).

Greenwich Mean Time of Observation.	* - * R.A.			* - * R.A.			* - * Declina- tion.			No. of Comparisons (δ)	Apparent Declination of Comet.	Log. Factor of Parallax in (α)	Letter of Refer- ence.
	h	m	s	h	m	s	'	"					
1896 Nov. 5	7 42	30.3	+0 12.42	Ret.	20 17	9.61	- 9	49.0	Ret.	+23 2	4.6	+9.3254	0.6798 <i>a</i>
5	7 42	30.3	-1 35.89	"	20 17	9.36	+ 7	47.6	"	+23 2	2.5	+9.3254	0.6798 <i>b</i>
8	6 49	50.0	-0 16.81	"	20 12	33.87	+ 3	28.7	"	+20 41	26.2	+9.1968	0.6918 <i>c</i>
13	7 50	10.2	-0 40.93	25	20 6	9.27	+ 7	5.9	5	+16 57	55.8	+9.4260	0.7558 <i>d</i>
26	6 0	36.4	-0 7.94	20	19 55	42.57	+ 6	37.3	4	+ 8 53	27.0	+9.3035	0.8002 <i>e</i>
26	6 0	36.4	+1 31.52	20	19 55	42.39	- 7	30.4	4	+ 8 53	24.9	+9.3035	0.8002 <i>f</i>
29	6 26	39.2	+0 35.34	Ret.	19 54	10.58	+ 2	33.6	Ret.	+ 7 16	47.2	+9.3939	0.8153 <i>g</i>
30	6 22	14.9	-1 13.21	"	19 53	43.52	+ 6	20.4	"	+ 6 45	59.7	+9.3939	0.8179 <i>h</i>
30	6 22	14.9	-1 8.82	"	19 53	43.40	-10	1.7	"	+ 6 46	4.2	+9.3934	0.8179 <i>i</i>

Notes

February 22.—Comet tolerably bright, but the selection of definite point for observation difficult. February 23.—The comet seemed much fainter, and the separate measures are very discordant. March 1.—Interruptions from clouds. The stars of comparison too far away in declination; the right ascension very uncertain. March 4.—Observation unsatisfactory; an attempt to repeat the observation with the reticule micrometer failed on account of clouds. March 21.—Comet v. ft.; observation doubtful.

April 21.—Comet tolerably bright, especially towards the south-east, which is the point selected for observation. April 28.—Comet well seen, notwithstanding bright moonlight. May 1.—Comet appears much fainter; the sky rather light, though the Moon had not risen. May 7.—Observation very unsatisfactory with either micrometer; the mean of the whole of the measures is given. May 9.—Interrupted by clouds. May 13.—Comet exceedingly faint; further observation probably impossible. May 16.—Brightness much the same as on May 13; comet just visible; no alteration noticeable. June 2.—Some of the measures rejected evidently had no reference to the comet, which could only be seen at intervals by glimpses.

Nov. 5.—Comet very faint and difficult to pick up; separate measures discordant. Nov. 8.—Only three observations possible on account of cloud. Nov. 26.—Comet very faint, but central stellar condensation suspected.

*Assumed Mean Places of Stars of Comparison.**Comet I. 1896 (Perrine-Lamp).*

Date.	Star's Designation or Authority for Place.	Mean R.A. 1896 ^o .	Correction to Mean R.A.	Mean Declination 1896 ^o .	Correction to Mean Dec.	Letter of Reference.
1896.						
Feb. 22	W. B. ₂ xx. No. 1808	h m s 21 0 6.39	-0.76	° ' " +27 53 34.8	-10.9	a
22	Micrometer obs. from (a) and prime vertical	20 58 23.14	-0.77	+27 54 42.6	-10.7	b
23	Bonn Obs., vol. vi. No. 4150	21 20 9.55	-0.94	+32 30 33.7	-8.9	c
Mar. 1	A. G. Z. Camb. (U.S.), No. 172	0 20 42.36	-1.44	+50 42 15.8	+8.7	d
1	" " No. 166	0 19 42.66	-1.45	+50 59 40.4	+8.7	e
3	" " No. 535	1 4 21.76	-1.16	+51 34 32.4	+12.3	f
4	" " No. 703	1 28 18.82	-1.00	+51 37 15.4	+13.8	g
4	" " No. 709	1 29 7.51	-1.00	+51 37 54.7	+13.9	h
9	Bonn, No. 2312	2 36 29.59	-0.32	+49 56 31.6	+16.8	i
9	Camb. (U.S.), No. 1246	2 35 34.90	-0.36	+50 1 9.9	+16.4	j
11	Bonn, No. 2315	2 51 16.73	-0.20	+49 9 15.2	+17.0	k
11	" No. 2321	2 51 45.06	-0.20	+49 5 24.0	+17.0	m
16	" No. 2999	3 26 57.48	+0.11	+46 55 29.3	+17.1	n
19	" No. 3125	3 37 23.38	+0.20	+45 46 14.1	+16.8	n
21	" No. 3240	3 46 42.41	+0.25	+45 12 8.4	+16.5	o

Comet III. 1896 (*Swift*).

Date. 1896.	Star's Designation or Authority for Place.	Mean R.A. 1896 ^o . h m s	Correction to Mean R.A. s	Mean Declination 1896 ^o . ° ' "	Correction to Mean Dec. "	Letter of Reference.
Apr. 21	Leiden Zones, Nos. 11, 243	3 31 2'55	+0'07	+30 46 33'0	+ 9'3	<i>a</i>
22	" " No. 148	3 32 19'92	+0'03	+33 30 59'7	+ 9'6	<i>b</i>
23	Lund Zones, Nos. 75, 79	3 25 7'02	+0'02	+36 7 42'5	+ 9'6	<i>c</i>
24	" " Nos. 92, 105	3 24 20'71	-0'09	+38 47 31'1	+ 9'8	<i>d</i>
24	" " Nos. 340, 498	3 27 12'70	-0'09	+38 57 19'8	+ 9'9	<i>e</i>
28	A. G. Z. Bonn, No. 2730	3 9 21'32	-0'36	+47 53 44'8	+ 9'6	<i>f</i>
28	" " No. 2732	3 9 37'40	-0'36	+47 44 41'0	+ 9'6	<i>g</i>
29	Bonn Obs., vol. vi. No. 873	3 5 45'96	-0'45	+50 3 57'0	+ 9'4	<i>h</i>
29	A. G. Z. Bonn, No. 2695	3 6 41'19	-0'45	+49 59 24'3	+ 9'4	<i>i</i>
May 1	" Camb. (U.S.), No. 1379	2 59 46'29	-0'64	+53 42 39'1	+ 9'0	<i>j</i>
1	" " " No. 1381	2 59 52'56	-0'64	+53 42 31'6	+ 9'0	<i>k</i>
3	A. G. Z. Helsingfors, No. 2591	2 46 22'80	-0'82	+56 54 26'0	+ 8'0	<i>l</i>
3	" " No. 2568	2 44 47'99	-0'82	+56 49 38'7	+ 8'0	<i>m</i>
4	" " No. 2404	2 32 25'41	-0'97	+58 12 38'3	+ 6'9	<i>n</i>
4	Rümker, No. 1403	2 40 34'84	-0'95	+58 23 44'8	+ 7'2	<i>o</i>
5	A. G. Z. Helsingfors, No. 2370	2 29 37'95	-1'05	+59 38 5'8	+ 6'6	<i>p</i>
6	" " No. 2337	2 27 40'94	-1'14	+60 39 6'1	+ 6'3	<i>q</i>
6	" " No. 2341	2 27 58'03	-1'14	+60 45 32'6	+ 6'3	<i>r</i>
7	" " No. 2205	2 16 59'61	-1'27	+62 0 4'4	+ 5'4	<i>s</i>
7	" " No. 2249	2 20 24'27	-1'24	+61 44 58'5	+ 5'6	<i>t</i>
8	" " No. 2111	2 12 40'96	-1'34	+62 52 21'1	+ 4'8	<i>u</i>
8	" " No. 2002	2 8 7'40	-1'35	+62 45 1'6	+ 4'5	<i>v</i>
9	" " No. 2058	2 10 45'75	-1'43	+63 56 34'0	+ 4'5	<i>w</i>

Date.	Star's Designation or Authority for Place.	Mean R.A., 1896 ^o .	Correction to Mean R.A.	Mean Declination 1896 ^o .	Correction to Mean Dec.	Letter of Reference.
May 9	A. G. Z. Helsingfors, No. 2098	h m s 2 12 13.35	-1.42	+63 51 24.9	+4.6	<i>x</i>
10	" " No. 1887	2 0 52.96	-1.50	+64 32 32.0	+3.5	<i>y</i>
10	Greenwich 10-Year Catalogue, 1880, No. 314	1 56 50.70	-1.51	+64 36 13.7	+3.2	<i>z</i>
11	A. G. Z. Christiania, No. 340	1 46 23.63	-1.63	+65 40 3.5	+2.0	<i>aa</i>
12	" " No. 328	1 41 22.84	-1.66	+66 16 0.5	+1.9	<i>bb</i>
12	" " No. 336	1 44 47.64	-1.66	+66 13 18.0	+1.9	<i>cc</i>
13	" " No. 327	1 40 17.88	-1.74	+66 41 7.7	+1.2	<i>dd</i>
16	" " No. 245	1 12 50.54	-1.80	+68 33 7.5	-0.4	<i>ee</i>
19	" " No. 189	0 54 40.55	-1.86	+69 57 38.4	-3.1	<i>ff</i>
19	" " No. 177	0 51 21.28	-1.84	+69 56 1.4	-3.4	<i>gg</i>
June 2	Bonn Observations, vol. vi. No. 1099	23 15 53.32	-0.61	+72 44 9.7	-9.9	<i>hh</i>

Comet I. 1897 (Perrine, November 2).

Nov. 5	A. G. Z. Berlin, No. 7657	20 16 54.91	+2.28	+23 11 34.8	+18.8	<i>a</i>
5	" " No. 7673	20 18 42.97	+2.28	+22 53 56.1	+18.8	<i>b</i>
8	" " No. 7610	20 12 48.42	+2.26	+20 37 40.0	+17.5	<i>c</i>
13	Munich Observations, vol. i. No. 23406	20 6 47.91	+2.29	+16 50 34.5	+15.4	<i>d</i>
26	" " " No. 22619	19 55 48.19	+2.32	+8 46 39.0	+10.7	<i>e</i>
26	" " " No. 22505	19 54 8.55	+2.32	+9 0 44.6	+10.7	<i>f</i>
29	" " " No. 22473	19 53 32.88	+2.36	+7 14 3.8	+9.8	<i>g</i>
30	" " " No. 22554	19 54 54.37	+2.36	+6 39 29.6	+9.7	<i>h</i>
30	Bonn Observations, vol. vi. No. 4391	19 54 49.86	+2.36	+6 55 56.2	+9.7	<i>i</i>

Liverpool Observatory : 1897 May 12.

Observations of Comets, Perrine, 1896 Nov. 2, and Perrine, 1896 Dec. 8, at the Radcliffe Observatory, Oxford.

(Communicated by E. J. Stone, Esq., M.A., F.R.S., Radcliffe Observer.)

The following comet observations were made with the 10-inch Barclay Equatorial, using the ring micrometer, with power 100 :—

Comet Perrine 1896 Nov. 2.

Date.	G.M.T.	Local Sidereal Time.	Observer.	Comet minus Star (corrected for Refraction only).	No. of N.P.D. Comps.	Apparent Comet.	Parallax in R.A. p.	Log. (p × Δ).	Apparent N.P.D. Comet.	Parallax in N.P.D. q.	Log. (q × Δ).	Ref.
1896. Nov. 6	h m s 7 39 52	h m s 22 40 52	W.	m s +0 18'98	9	20 15 30'60	+0'15	9'3690	67 45 53'6	3'0	0'6740	(a)
9	7 22 38	22 35 25	W.	-1 37'41	4	20 11 7'45	+0'14	9'3592	70 5 36'0	3'1	0'6975	(b)
9	7 22 38	22 35 25	W.	-2 17'03	4	20 11 7'50	+0'14	9'3592	70 5 36'6	3'1	0'6975	(c)
26	7 46 6	0 5 59	R.	...	7	...	...	...	81 8 56'4	3'6	0'8085	(d)
26	7 47 42	0 7 35	R.	-0 4'25	7	19 55 39'65	+0'18	9'5173	...	...	...	(d)
30	7 1 1	23 36 33	W.	-1 13'17	4	19 53 43'50	+0'17	9'4825	83 15 1'5	3'5	0'8125	(e)
30	7 1 1	23 36 33	W.	-2 36'81	4	19 53 43'57	+0'17	9'4825	83 14 58'4	3'5	0'8125	(f)
Dec. 7	6 24 46	23 27 48	R.	-0 43'96	6	19 51 17'81	+0'16	9'4719	86 34 36'6	3'5	0'8261	(g)

Comet Perrine 1896 Dec. 8.

Dec. 11	8 41 21	2 0 31	W.	-1 55'96	3	1 10 19'25	+0'24	8'9013	84 38 33'1	18'8	0'8044	(h)
12	8 14 2	1 37 4	R.	-0 45'31	8	1 17 16'32	+0'09	8'4986	85 2 24'5	18'7	0'8066	(i)
1897. Jan. 23	8 54 35	5 3 19	R.	-1 35'92	6	4 44 52'53	+0'05	8'4704	90 20 21'9	12'5	0'8411	(j)
26	8 14 55	4 35 23	R.	+0 25'24	12	4 53 47'69	-0'05	8'4698	90 6 46'6	11'8	0'8398	(k)

Observers' Remarks.

- (a) Observations very difficult owing to the extreme faintness of the object. Instrument white with hoar frost at end of observations, object-glass thinly covered with moisture. Sky hazy.
- (b), (c) Sky very hazy. A small and very faint cluster of three or more stars is near, which in the fog resembles the Comet.
- (d) Comet fairly bright with a nucleus of about the 12th magnitude. The comparison star is inconveniently close to the Comet for ring-micrometer work. Observed in breaks of rapidly passing clouds. Wind squally.
- (e), (f) Comet is brighter than at my last observation; and, I believe, has a tail, widely fan-shaped, extending northward, but much fainter than coma. Foggy to-night in S.W.
- (g) Nucleus 12 magnitude. Coma $1\frac{1}{2}'$ diameter.
- (h) Observations unsatisfactory. Instrument dripping with moisture; wiped object-glass twice, but it was rapidly coated again with condensation. Comet is about $9\frac{1}{2}$ or 10 magnitude; but there is much moonlight.
- (i) Moonlight strong; centre of a very faint nebulous condensation observed.
- (j) Comet is a rather faint, nebulous mass, $2'$ in diameter, with a condensation.
- (k) Comet is a faint nebulosity of $2'$ diameter, with a condensation. Observations rather difficult.

Assumed Places of the Comparison Stars.

Ref.	Mean R.A.			Reduction to Apparent R.A. s.	Mean N.P.D.	Reduction to Apparent N.P.D. "	Authority.
	h	m	s				
(a)	20	15	9.33	+2.29	67 45 7.9	-18.3	Berlin B., A.G. 7639
(b)	20	12	42.57	+2.29	70 5 40.1	-17.2	Berlin A., A.G. 8079
(c)	20	13	22.24	+2.29	69 59 52.7	-17.3	Berlin A., A.G. 8087
(d)	19	55	41.57	+2.33	81 9 39.7	-10.8	Bessel's Equatorial comparisons with Schjellerup, 7741, Lamont, 22619; Lamont, 22819; Glasgow (1870), 5000

Ref.	Mean R.A. h m s	Reduction to Apparent R.A. s	Mean N.P.D.	Reduction to Apparent N.P.D. "	Authority.
(e)	19 54 54.31	+ 2.36	83° 20' 30.8"	- 9.7	Bonn vol. vi. + 6° 4393
(f)	19 56 18.02	+ 2.36	83 20 20.1	- 9.8	Bonn vol. vi. + 6° 4401
(g)	19 51 59.37	+ 2.40	86 37 2.1	- 7.9	Barclay Equatorial comparisons with Albany, 6936
(h)	1 12 11.01	+ 4.20	84 39 47.9	- 27.2	Albany A.G., 353
(i)	1 17 57.41	+ 4.22	85 1 59.0	- 26.9	Radcliffe Transit-circle observation, 1896 Dec. 15
(j)	4 46 26.61	+ 1.84	90 20 37.0	- 3.4	Radcliffe Transit-circle observations, 1897 Feb. 17, 20
(k)	4 53 20.60	+ 1.85	90 7 20.7	- 3.1	Radcliffe Transit-circle observations, 1897 Feb. 17, 20

In the computation of the parallaxes the adopted value of the Sun's mean horizontal parallax is 8".85; and the geocentric distances, Δ , are taken from the *Astronomische Nachrichten*, as follows:—(a), (b), (c), No. 3386; (d), (e), (f), (g), No. 3387; (h), (i), No. 3391; (j), (k), No. 3396.

Observation of Comet Perrine (1896 Dec. 8) with the Transit-Circle.

Date.	G.M.T. of Transit. h m s	Observer.	Apparent R.A. of Comet. h m s	Apparent N.P.D. of Comet. ° ' "	Parallax N.P.D. q.	Log. (q × Δ), q.	Observer's Remarks.
1896. Dec. 11	7 51 2	W.	1 10 3.88	84 37 49.3	18.8	0.8035	Sky very thick; moonlight and haze. Observation very difficult. The microscope readings have been increased by 1 rev. = 1'

In the computation of the parallax the adopted value of the Sun's mean horizontal parallax is 8".85; and the geocentric distance, Δ , is taken from the *Astronomische Nachrichten*, No. 3391.

Observers: W., Mr. W. Wickham; R., Mr. W. H. Robinson.

Zodiacal Radiants of Fireballs. By W. F. Denning.

I have previously pointed out that the majority of large fireballs observed *move slowly, are directed from radiants in the western half of the sky and in the neighbourhood of the horizon* (*Monthly Notices*, vol. liv. pp. 342 and 539). They appear, in fact, to form a special class of bodies, and to offer well-marked distinctions to the ordinary shower-meteors generally moving swiftly from radiants high in the eastern sky.

To what has been already said on this subject I may now add that the majority as well as the most prominent of the fireball radiants apparently cluster in a girdle conforming approximately with the position of the ecliptic. This is not an inviolable law of distribution, for many exceptions to it can be found, but it agrees with the weight of the evidence, and much of this is of a very suggestive and significant kind.

There are probably few persons who have occupied themselves in the comparison and assortment of well-marked fireball radiants, but those who have will remember the brilliant Cancerids of January, Sextantids of February, β Leonids of March, Virginids and Librids of April, Scorpiids and Sagittarids of June, Aquilids, Capricornids and Aquarids of July and August, Piscids of September, Arietids of October, Taurids of November, and Geminids of December.

I have compiled the following table as representing approximately the facts observed:—

	R.A. Fireball Radiants.		Chief Positions.
		°	{ 97° + 29°
Jan.	110	Geminids, Cancerids	{ 110 + 24
			{ 132 + 21
Feb.	140	Sextantids, Hydrids	{ 145 + 5
			{ 148 - 12
Mar.	170	Sextantids, β Leonids	175 + 10
April	200	Virginids, Librids	{ 208 - 10
			{ 216 - 8
			{ 228 - 3
May	230	Serpentids, Scorpiids, Ophiuchids	{ 235 - 15
			{ 244 + 7
June	260	Scorpiids, Sagittarids	{ 250 - 20
			{ 269 - 23

	R.A. Fireball Radiants. °		Chief Positions.
July	290	Antinoids, Aquilids	$\left\{ \begin{array}{l} 282^{\circ} - 13 \\ 285 - 21 \\ 296 - 0 \\ 303 + 12 \end{array} \right.$
Aug.	320	Capricornids, Aquarids	$\left\{ \begin{array}{l} 303 - 12 \\ 317 - 11 \\ 326 - 9 \\ 339 - 12 \end{array} \right.$
Sept.	350	Piscids	$\left\{ \begin{array}{l} 348 \pm 0 \\ 355 + 5 \\ 2 - 3 \\ 6 + 12 \end{array} \right.$
Oct.	20	Piscids, Arietids	$\left\{ \begin{array}{l} 14 + 7 \\ 33 + 18 \\ 40 + 20 \end{array} \right.$
Nov.	50	Arietids, Taurids	$\left\{ \begin{array}{l} 48 + 22 \\ 55 + 17 \\ 62 + 22 \end{array} \right.$
Dec.	80	Aurigids, ζ Taurids, Geminids	$\left\{ \begin{array}{l} 77 + 32 \\ 80 + 23 \\ 108 + 25 \end{array} \right.$

It is not to be assumed from the table that the approximate R.A. of the principal fireball-radiants exhibits a regular arithmetical increase of 30° per month, but that this rate of progression seems best to generally satisfy the observations. The R.A. given is chiefly based on the very well-defined April fireball-radiants in Virgo and Libra, the Scorpiid radiant in June, the Capricornid radiant in August, the Arietid radiant in October, and the Taurid radiant in November. Any system of R.A.'s for the different months, to be conformable with the principal showers of large meteors, must accommodate these specially productive and well-known systems.

In striking corroboration of the preference for the zodiac shown by fireball-radiants it may be mentioned that the well-defined positions in *Virgo*, *Libra*, *Scorpio*, *Sagittarius*, *Capricornus*, and *Aquarius* are visible, notwithstanding the circumstance that they are below the equator, and therefore unfavourably presented in northern latitudes. Yet they form a well-marked girdle along the zodiac, while a similar distance north of the equator few such radiants are manifested. Again, if we turn to the region embraced by *Pisces*, *Aries*, *Taurus*, *Gemini*, *Cancer*, and *Leo* there

appears the same extensive girdle, while south of the equator not many fireball radiants are known. But, as before stated, the zodiacal radiants of fireballs are not nearly inclusive of all such systems, for there are instances in *Cygnus* ($293^{\circ} + 52^{\circ}$ August, and $304^{\circ} + 54^{\circ}$ September), *Cepheus* ($330^{\circ} + 57^{\circ}$ January–March, and $335^{\circ} + 71^{\circ}$ August–September), *Cassiopeia* ($20^{\circ} + 57^{\circ}$ April), *Draco* ($262^{\circ} + 63^{\circ}$ October), *Pegasus* ($336^{\circ} + 35^{\circ}$ September), *Ursa Major* ($213^{\circ} + 53^{\circ}$ August), *Perseus* ($47^{\circ} + 44^{\circ}$ April), &c., &c., but the fireballs from the region of the zodiac seem to have been the most numerous, and the radiants derived from them more satisfactory than the others.

These large meteors would therefore appear to be revolving not only in direct orbits, but to exhibit small inclinations like the Jovian family of comets.

It is most important that large meteors, whenever and wherever they appear, should be accurately recorded in order to acquire the material which is absolutely necessary in an investigation of this kind. In the present state of our knowledge it is difficult to draw certain conclusions, the available data being not only deficient, but often vitiated by unreasonably large errors. In view of the suggestive and interesting questions involved, it is hoped observers of the brilliant and isolated forms of meteoric phenomena offered by fireballs will be particular in registering their apparent paths amongst the stars, and durations of flight, so that trustworthy results may accumulate more rapidly than in previous years

Bristol: 1897 April 11.

The New Thompson Photographic Telescope at the Royal Observatory, Greenwich.

The Astronomer Royal announced that the new instrument, presented by Sir Henry Thompson, had been mounted on the Physical Observatory under the Lassell Dome, and was practically completed and in working order, though further adjustment of the object-glass would be required.

He exhibited some photographs of the Moon, (i) taken at the principal focus and giving an image about $2\frac{1}{2}$ inches in diameter, (ii) enlargements made at the telescope by the use of a secondary magnifier, giving an image $11\frac{1}{2}$ inches in diameter.

